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Packing and shipping in the 48 states:	8"—$105; 10"—$145

■*All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

■For dealer or catalog information see the Meade **ED Apochromatic Refractor** ad in this issue.

MEADE LX200 SMC
Meade
MEADE LX200 SMC
MEADS LX200
SMART DRIVE
Meade
ENTER MODE GO TO
N W E S
Meade

PRICE INCREASE! Prices on Meade 8" and 10" LX100/LX200 SCT's will increase on June 1, 1993.

Optics: research-grade SC optics, the finest ever offered the advanced amateur. Specify either f/6.3 or f/10.

Multi-Coated Optics (not available on any competing Schmidt-Cassegrains) are standard equipment.

Each LX200 includes 8 x 50mm viewfinder, diagonal prism, and Series 4000 SP26mm eyepiece.

Meade 10" LX200

Power Consumption: Operate your LX200 all night from an auto cigarette lighter plug with **zero** risk of battery drain, or use the standard equipment 115v.AC adapter. Competing computer telescopes use up to **16 times** more electric current **and require you to carry around a 44-lb. storage battery (and purchase a battery recharger) just to operate the telescope!**

Meade Smart Drive™ (not available on competing computer telescopes) yields an observatory standard 5 arc. sec or less of periodic tracking errors.

Altazimuth Operation: Just set up your LX200 directly on the tripod (without a wedge!) and observe. The telescope's computer tracks on **both** axes to keep objects precisely centered.

Power Panel connectors for RS-232, CCD cameras, electric focuser, illuminated reticle eyepiece, and more.

Meade 8" LX200

The largest, most rigid fork mountings ever manufactured for commercial Schmidt-Cassegrains.

Enter any of 747 library objects into the keypad, press GO TO and the telescope slews to the object at 8°/sec. (8000-object library available optionally at $99*.)

Digital and Information Readouts conveniently read directly from the hand-held keypad controller.

Pushbutton electric slew: press RA or Dec slew and the telescope moves at 8°/sec on both axes.

Optional 8" wedge or 10" superwedge, shown, is required only for long-exposure astrophotography.

4-speed operation on both axes: 2x, 32x, 2°/sec., 8°/sec.

Enter into the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8°/sec.

LX200 SCHMIDT-CASSEGRAINS

The largest-selling serious telescopes in the world.

Now you can buy the most advanced 8" and 10" Schmidt-Cassegrains ever produced, at a price directly competitive with other SCT's offering only a fraction of the features!

Meade LX200 SCT's offer a revolutionary departure from any other SCT's ever made available. Consider the **standard specifications** of these telescopes:

New Heavy-Duty Fork Mounts—The largest, most rigid in the industry. *Meade 8" and 10" LX200 fork mounts yield the lowest damping times of any SC fork mounts available.* Large 4"-diameter polar ball bearings complemented by DC-servo-motor-driven worm gears on ***both*** telescope axes permit observatory-level precision in tracking, guiding, and slewing.

100% Computer-Controlled Operation—All-new Meade LX200 microprocessor-controlled drive systems offer an incredible array of features:

■**Four-speed operation on both telescope axes** simultaneously, including (a) photo-guiding (at **2x** sidereal rate); (b) image centering and microslewing in the main telescope (at **32x** sidereal rate); (c) image centering in the viewfinder (at **2**° per sec.); or fast-slew of the main telescope across the skies (at **8**° per sec.).

■**Pushbutton Electric Slew**—Press RA or Dec slew, east or west, north or south, and the telescope moves at 8° per sec. on both axes. As you near a desired object, flip to 2° per sec. slew, to center the object in the field. The observer need never touch the telescope in moving from one object to another. (Of course, if you wish, the telescope may be moved manually as well.)

Current (mA x 100)
MEADE LX200
COMPUTER DRIVE SYSTEM
LX QUARTZ - DC SERVO MOTOR
SMART DRIVE
On Off
N S
Encoders
RS232
Focuser
Reticle
Keypad
Power 12 vDC
CCD

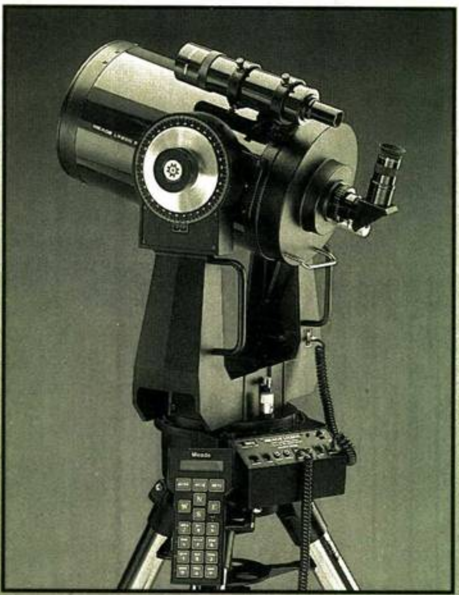
■**Digital Readouts** on both axes, read from the handheld Electronic Command Center (ECC).

■**GO TO Capability**—Enter the RA and Dec of an object into the keypad of the ECC, press GO TO, and the telescope automatically slews to the object at 8° per sec., centering it in the field.

■**747-Object Built-in Library**—Enter any of the 110 Messier objects, 278 of the finest NGC objects, 351 stars (doubles, variables, polar reference stars), or one of the 8 planets, from Mercury to Pluto, press GO TO, and the telescope slews at 8° per sec. to the object with uncanny precision. For $99* add the 8000-object Meade CNGC library, a 30-second plug-in.

■**Permanently programmable (PPEC) Smart Drive**™, capable of reducing periodic drive errors to 5 arc. sec. or less.

Legendary Meade Super Multi-Coated f/6.3 or f/10 Schmidt-Cassegrain Optics—Now you can choose either wide-field f/6.3 or classical f/10 Meade US-made SC optics **at the same price.** Either way, you'll be buying the finest Schmidt-Cassegrain optical system available, a system that yields razor-sharp stellar images and high-resolution observing of the Moon, planets, and deep-space, from the World's leading manufacturer. Meade exclusive Super Multi-Coatings on both sides of the correcting plate assure maximum light transmission and contrast.



Altazimuth Mode Operation—For all visual observing applications, and for lunar and planetary photography, Meade LX200's may be set up in the altazimuth mode, without any equatorial wedge—just attach the telescope's drive base directly to the tripod, use the fast 1-star alignment procedure, and the telescope's computer actuates 2-axis tracking that keeps objects precisely centered in the field, even at high powers, during the entire observing session. For long exposure photography (longer than about 5 minutes) altazimuth-induced field rotation requires an equatorial wedge, which may be purchased separately.

Fast Polar Alignment—Center two reference stars in the telescopic field and the telescope's computer tells you exactly what telescope controls to actuate for precise polar alignment in the equatorial mode in less than a minute.

The widest array of keypad and power-panel control functions—In addition to the microprocessor-controlled operations listed above, the handheld ECC and the telescope's power panel permit: readout of sidereal or local time; actuation of the optional electric focuser; crossline brightness control of an illuminated reticle eyepiece; direct plug-in of popular CCD autoguiders/imagers; and more than 14 other telescope functions.

MEADE LX100 SCHMIDT-CASSEGRAINS

Observers not requiring the sophistication of the LX200 electronics may wish to consider an 8" or 10" LX100 model SCT instead. Meade LX100's include the exact same heavy-duty fork mounts of their LX200 counterparts, but with a microfine declination tangent arm control in place of the LX200's motorized worm gear, and with a 2-speed drive in place of the LX200's 4-speed drive; optical tubes and coatings are identical. Standard LX100 features include:

■ Handheld Electronic Command Center—With 2-speed operation, **2x** for photo-guiding and **32x** for image centering and microslewing in the main telescope. (With the optional DC-servo declination motor installed, these speeds are operational on both telescope axes.)

■ Permanently programmable (PPEC) Smart Drive, as described above.

Complete LX100 and LX200 Telescopes

Specifications: 8" and 10" LX200's—Each complete telescope includes: 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount, with 4" polar ball bearing, dual-axis 5.75" worm-gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld keypad Electronic Command Center, with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cords for telescope operation from either 12 v. DC auto cigarette lighter plug or 115v.AC; 8 x 50mm viewfinder with crosshairs; diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece; variable-height field tripod; new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

Specifications: 8" and 10" LX100's—Each complete telescope includes 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, 5.75" RA worm gear, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld pushbutton Electronic Command Center with PPEC Smart Drive and 2-speed drive control; 25 ft. power cords for telescope operation from either 12v. DC auto cigarette lighter plug or from 115v. AC; viewfinder: 6 x 30mm (8") or 8 x 50mm (10"); diagonal prism (1.25"); Series 4000 Plössl 26mm eyepiece; variable-height field tripod; equatorial wedge (8") or Superwedge (10"); new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

For the beginner, or for the most seasoned observer, Meade LX200's are the most user-friendly telescopes ever manufactured. First-time telescope users **almost uniformly** remark that "I saw **hundreds** of deep-space objects my very first night out!" Advanced amateurs report that "the LX200 found objects during my first observing session that I was unable to locate in over 20 years of serious observing with other telescopes."

Contact your authorized Meade dealer today. See for yourself why Meade LX200's are the largest-selling serious telescopes in the world.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
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ON THE COVER: Cosmologists studying the motions of galaxies, like the Sombrero Galaxy (M104) shown here, calculate that the universe began no more than 14 billion years ago. But stellar astronomers are convinced that globular clusters formed 16 to 19 billion years ago. See page 38 to find out how astronomers are trying to resolve this paradox. National Optical Astronomy Observatories photo.

Frank Zullo

ON ANY CLEAR NIGHT throughout the year, you can see the stars in the northern sky endlessly circling Polaris. To learn about these ever-present stars and their host constellations, see page 68.

20th ANNIVERSARY YEAR

ASTRONOMY

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Astronomy (ISSN 0091-6358) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Editorial telephone: (414) 796-8776; Advertising and Dealer Orders: (800) 558-1544; Customer Service — Consumer product and subscription inquiries: (800) 446-5489 weekdays 8:30 a.m. to 5:00 p.m. Central Time; Consumer product and subscription orders only: (800) 533-6644 7 days a week, 24 hours a day; Fax: (414) 796-0126. Copyright © 1993 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second-class postage paid at Waukesha, WI, and additional mailing offices. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with the current issue. Subscription price: 1 year, $24. All foreign: add $6 per year; please remit in U.S. funds. GST #R122713209. Send editorial and business inquiries and submissions to the address above. Not responsible for unsolicited materials. Astronomy is indexed in *The Reader's Guide to Periodical Literature* and indexed and abstracted in *Academic Abstracts* and *Magazine Article Summaries.* Microfilms of Astronomy available from University Microfilms, Inc., 300 North Zeeb Road, Ann Arbor, MI 48106. POSTMASTER: Send address changes to Astronomy, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Canadian second-class postal permit no. 545775. Printed in the U.S.A.

The Audit Bureau

Behind the Scenes

BETTER TELESCOPES IN A SINGLE STEP

Do the blurry-view blahs ever get you down? Are fuzzy star clouds and nebulae starting to leave you cold? Do you sometimes think your telescope should "star" in your next rummage sale? Well, you're not alone. But before you do anything rash, I suggest you try one simple thing that may reawaken your love affair with that telescope.

I'll give you a hint — it doesn't involve fiddling with the mounting. Give up? *Go buy a better eyepiece.* This may be all that's standing between you and a renewed interest in astronomical observing.

Good eyepieces are an often-overlooked key to happy viewing. With many low-priced consumer telescopes, manufacturers put as much as value as possible into the scope's main optics and mounting. After meeting those needs, they do what they can to provide the buyer with a basic set of eyepieces. For the most part these are adequate, but it's foolish to expect that they are going to be topnotch. They can't be. Relentless demand by consumers for low, low, low telescope prices won't allow it.

Thus many commercial scopes hit the market equipped with a handful of eyepieces that are OK but far from outstanding in quality. So where's the problem? The problem is that many beginners (the largest part of the telescope-buying public) end up thinking that the views they get with these basic eyepieces represent the best views their scopes can achieve. They almost never are — but how many observers lose interest in astronomy before pinpointing the problem?

The remedy is simple: upgrade your eyepieces. On page 56, you'll find a thoroughly detailed buyer's guide to the wonderful world of eyepieces. If you're fairly new to astronomy, prepare for a jolt: there are lots of them. Even well-seasoned observers may be surprised by the full variety of what's on the market. No matter what telescope you own, you can find something here to give its optical performance a real boost.

Faced with all the choices, it's tempting to splurge and get a whole slew of them. But you'll do better to start small. Even if you can afford it, don't rush out and replace your entire set of eyepieces right away. Instead think about the objects you observe most and the magnifications that give you the best views. Then get the one or two eyepieces you'll use most often.

Buying only a couple of new eyepieces to start with is sensible in another way, too. Because the out-of-pocket investment is less, you can afford to spend a bit more on each eyepiece you get. How much is enough? As a rough guide, figure on spending at least $50 to $100 for each new eyepiece. If this sounds high, remember that everything you see with your telescope passes through your eyepieces. Surely it's worth a few extra dollars for a crucial accessory that will never wear out.

Sincerely,

Robert Burnham
Editor

ASTRONOMY

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I.C.D., The Hearst Corp., New York, NY 10019
Canadian Newsstand Distribution
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Letters

A Rose by Any Other Name . . .

Robert Burnham's "Behind the Scenes" (March 1993) raised an intriguing question: What should we call CCD imaging? Why not combine the best parts of astrophotography and digital imaging in the magazine. Both methods will continue as important areas of the hobby and both produce beautiful results. Why not call the techniques of recording the sky by means of CCD cameras "digital astrographing?" — *Joseph A. Ronchetti, Cullman, Alabama*

Cast my vote for your suggested "astro-imaging." Anyone knowledgeable about medical diagnostic techniques recognizes the implications of imaging; the "astro" prefix leaves little doubt about what is being labeled or discussed.

As tools for astronomy I think CCDs are great. But may I suggest that you always label CCD images as such in the magazine? The power of CCDs bothers me somewhat: Those of us who do not know the extent of the image modification might conclude that the colors in a CCD image are "true."

I realize that astrophotographers have long used image manipulation techniques to bring out the most color and detail in their photos. But I trust the result to be something closely representing reality. I am somewhat less sure about computer image "retouching." — *Don Schroeder, Cincinnati, Ohio*

Your idea of a special name for CCD imagery is great. Perhaps the process of getting the images could be called digitography and the images themselves photonographs. — *Randy Watson, Aiken, South Carolina*

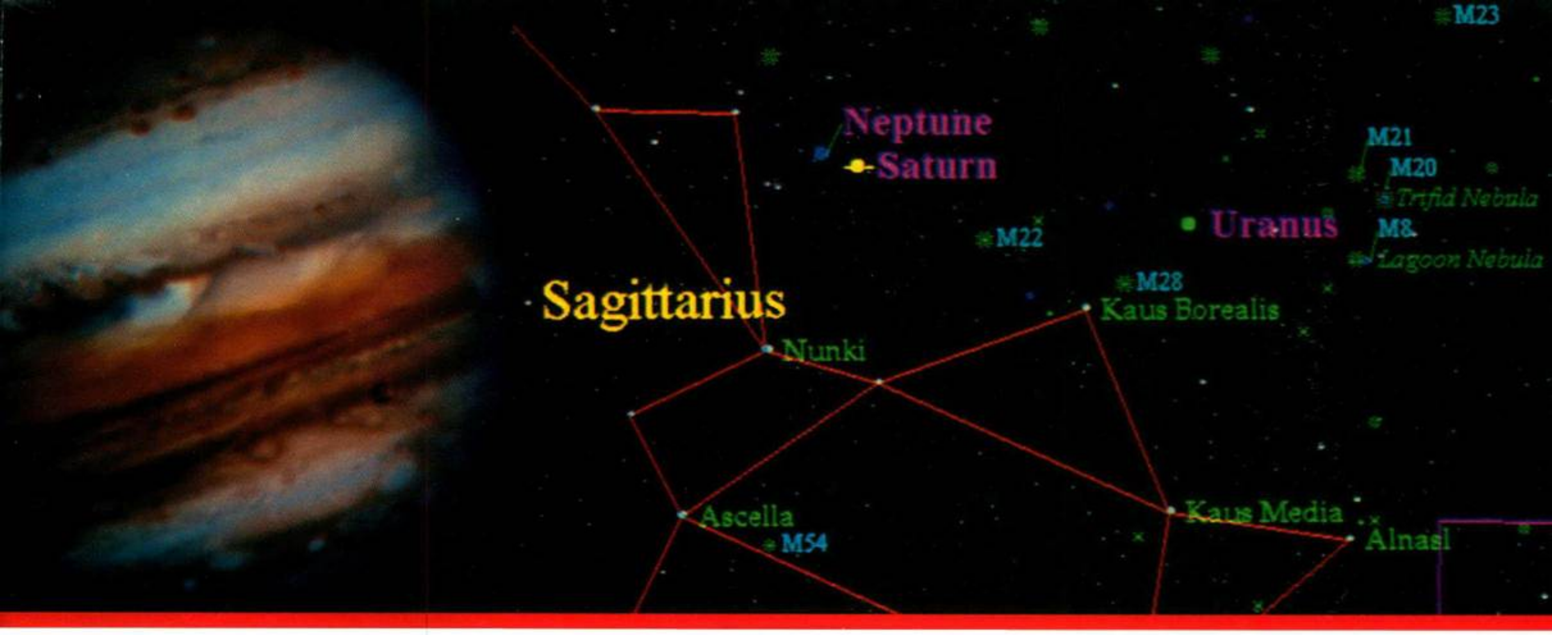
Is a Satellite Forever?

Your news item "New Satellite Could Last Forever" (February 1993) states that the LAGEOS II satellite may stay in orbit for billions of years, until the Sun becomes a red giant.

Presently the orbit of LAGEOS II is decaying at the rate of about 1 millimeter per day, which would bring it back to Earth in about 16 million years, assuming the decay rate stays constant.

However, the decay rate will not stay constant. About 70 percent of the decay is due to "thermal drag," which involves the spin of the satellite and the heating of the retroreflectors by Earth's infrared radiation. Thermal drag will last only for decades, until the satellite slows down enough for its rotation to become tidally locked with Earth.

[continued on page 12]



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Which is so simple to use that the world's greatest living writer of science fiction exalts it, yet so technically accurate that the world's greatest observatories like the Johnson Space Center use it to drive their telescopes?
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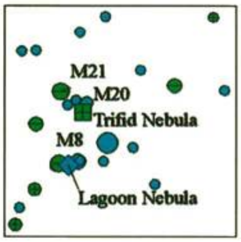

Plan your observation sessions with spectacular, professional-quality star chart printouts.

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>
> Arthur C.Clarke

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What software allows you to plan observation sessions with professional-quality star chart printouts, locate whatever object on the screen you want, then guide your conventional or automated telescope to position the real one, dead on in your telescope?
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Place deep-space objects right in your eyepiece faster than ever with the telescope link.

A friendly, powerful conclusion.

So for those who ever wondered at a falling star, or warmed to track the icy scarps of Neptune, or dreamed of sailing solar winds to distant galaxies and nebulae, where else is there to look?
Only TheSky.

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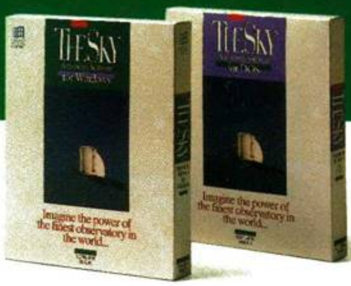
Astronomy Software



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The *Best-Ever* Eyepiece Sale from Meade!

Through June 30, 1993, you can receive Meade premium-grade Series 4000 eyepieces absolutely FREE! Just buy any of the eyepieces below at the regular price, and your Meade dealer will include the listed free eyepieces with your order. It's that simple. No coupons to send in, no waiting, no hassle!

Buy any TWO: Super Plössl 15, 20, 26, 32, or 40mm
And receive ONE: Super Plössl 6.4, 9.7, or 12.4mm FREE

Buy ONE: Super Wide Angle 40mm
And receive ONE: Super Wide Angle 18mm FREE

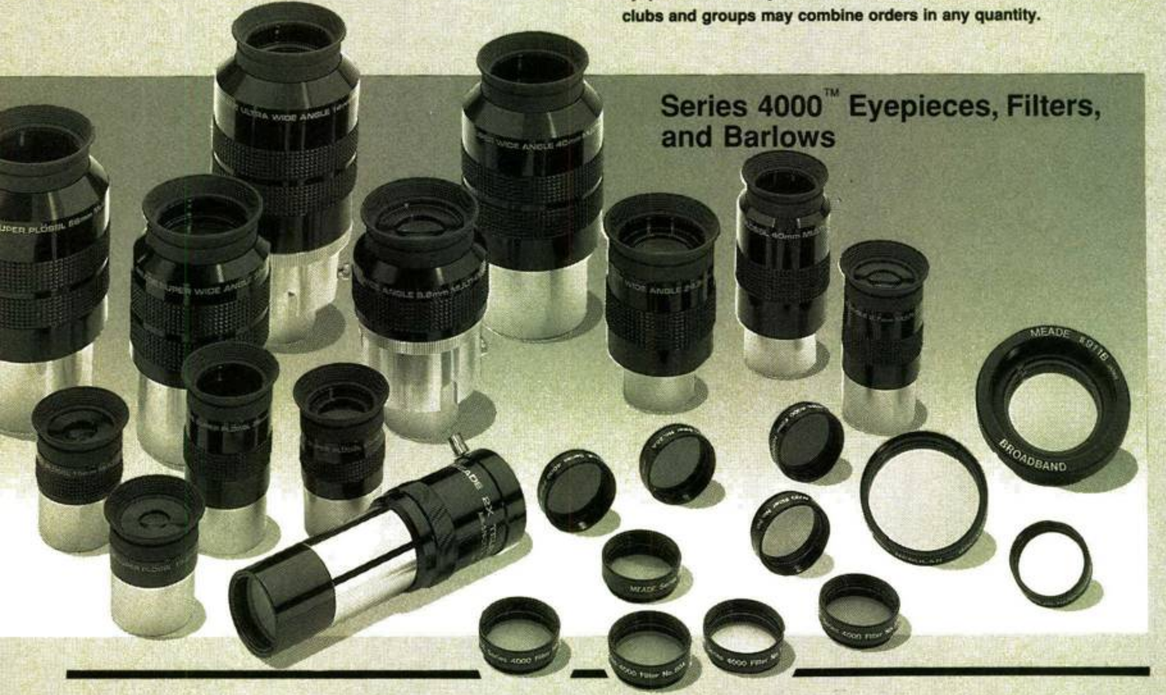
Buy ONE: Ultra Wide Angle 14mm
And receive ONE: Ultra Wide Angle 6.7mm FREE

Buy ONE: Super Wide Angle 32mm
And receive ONE: Super Wide Angle 13.8mm FREE

Buy ONE: Ultra Wide Angle 8.8mm
And receive ONE: Ultra Wide Angle 4.7mm FREE

Buy ONE: SWA 13.8, 18, 24.5mm, or SP56mm
And receive ONE: SP 6.4, 9.7, or 12.4mm FREE

Suggested USA mail-order retail prices for separate purchase of Meade Series 4000 eyepieces: Super Plössl (SP) 6.4, 9.7, 12.4, 15, 20, 26mm—$87.95 ea.; 32mm, 40mm—$109.95 ea.; 56mm—$229.95. Super Wide Angle (SWA) 13.8mm—$139.95; 18mm—$149.95; 24.5mm—$169.95; 32mm—$239.95; 40mm—$299.95. Ultra Wide Angle (UWA) 4.7mm—$154.95; 6.7mm—$187.95; 8.8mm—$229.95; 14mm—$269.95. This special offer is valid only between May 1, 1993 and June 30, 1993, at participating Meade dealers, and is subject to eyepiece availability on a first-come, first-served basis. Individuals, clubs and groups may combine orders in any quantity.



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World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Internal batteries included. Multi-coated optics. Bullseye reticle. 1.25" **$129.95** (3.29)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$109.95** (3.29)

MA 12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$94.95** (3.29)

MA 12mm–Same as above, but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$74.95** (3.29)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$99.95** (3.29)

Camera Adapters (1.25" & .965")

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": **$27.95** (2.79) 1.25": **$29.95** (2.79)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.79)

Tele-Extenders

TELE-EXTENDER

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos. **$29.95** (2.79)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece. **$39.95** (2.79)

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2X Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.29)

2x-3x Variable Barlow (1.25")

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Fine 4-element oculars that yield excellent image quality with any telescope. Computer-optimized design provides wide, flat fields, highly corrected for spherical and chromatic aberrations. Parfocal, multi-coated, 1.25" barrels. Threaded for filters. **Focal Lengths: OR 4, 6, 9, 12.5, 25mm.**

each **$49.95** (2.79)

Modified Achromatic Eyepieces

An improvement on the traditional Kellner design, the 3-element MA gives sharp, faithful, well-corrected images of the Moon, planets, and deep-space. Multi-coated; threaded for filters. 1.25" **Focal Lengths: MA 9, 12, 25, 40mm.**

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The finest focusers in the industry. Meade rack and pinion mechanisms have precise, ultra-smooth action along the entire travel distance. Housings are machined for tight fit of the moving sleeve. All focuser models may be used on tubes of from 4" to 20" diameter; all accept 1.25" eyepieces. Mounting hardware included.

#71—The finest economical focuser available. Travel distance: 2.2" A precision mechanism, beautifully finished. **$44.95** (2.79)

#67—Includes spring-loaded gearbox for variable tension adjustment. Travel distance: 2.2". **59.95** (2.79)

Rack-and-Pinion Focusers (2")

#680--The most popular 2" focuser ever manufactured. Thousands in use. Spring-loaded gearbox; 3" travel. Includes 1.25" and 2" eyepiece-holders. **99.95** (3.78)

#682—Low-profile 2" focuser; body height only 1.75". Spring-loaded gearbox. Travel: 2.5". Includes 1.25" adapter. **99.95** (3.78)

Viewfinders: 30mm, 50mm, 60mm

#637: 6 x 30mm--Fine, 7° wide-field finder; coated, achromatic lens; crosshair eyepiece, 2-ring bracket with alignment screws. Attaches to tube diameters 6" to 12" **$49.95** (3.29)

#545: 8 x 50mm- *(lower photo)* Wide 5° field; coated achromatic objective; crosshair eyepiece. White tube. Ideal for telescopes of any aperture. See bracket below. **69.95** (4.28)

#544: 8 x 50mm-- Same as #545, but in Meade blue. **69.95** (4.28)

#957: 9 x 60mm---*(top photo)* Collects 44% more light than 50mm; superior for faint objects; bracket below. **99.95** (4.68)

Bracket for 8 x 50mm: Fits Meade and Celestron SCT's, and other tubes from 7" to 20" diameter. **17.95** (2.79)

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Originally developed by Meade Instruments, these convenient diagonals erect the astronomical image, for terrestrial use of astronomical telescopes. Fully coated.

#927: for .965" focusers.
#928: for 1.25" focusers.
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HOW TO ORDER

- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA
Orders: 800-843-4780; Info: 818-505-8424.

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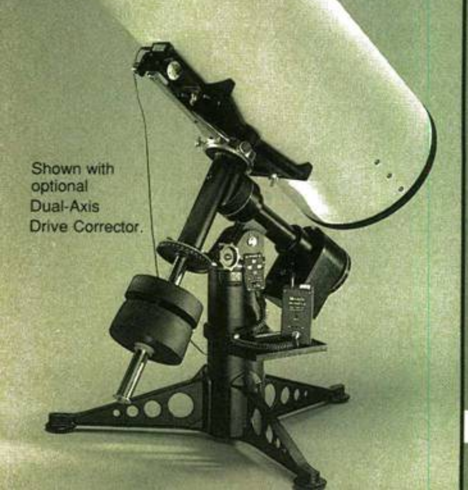
Starfinder 16: 16" f/4.5 $1995.

See the Meade General Catalog for details.



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■ **Optional Accessories:** See the opposite page for some of the many optional accessories available. Additional systems, including the **#55 Manual Declination Control**, **#43 Drive Corrector** and **#47M Dual-Axis Drive Corrector,** are described in the **Meade General Catalog.**

A Meade Starfinder telescope opens up the skies to an extremely wide range of serious visual observing, to lunar and planetary photography, and even to limited deep-space photography. And every telescope is backed by the World's largest manufacturer of serious telescopes.

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■ The 1993 Meade General Catalog—$3.00 postpaid—is available from any authorized Meade dealer or directly from Meade Instruments.

■ For further information call Meade *Instruments* at 714-556-2291 or contact one of these authorized mail-order dealers:

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ADVANCED PRODUCTS DIVISION **Meade Instruments Corporation**

10″ Model 2120A:
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8″ Model 2080A:
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4″ Model 2045D:
$659.*

4″ Model 2045D: the Ultraportable Meade SCT

For the beginning astronomer the lightweight and easy-to-use Meade 2045D packs a powerful potential for serious observing. As a second telescope for the advanced amateur, the 2045D permits wide-ranging observations in locations inaccessible or inconvenient to larger instruments. Each telescope includes optics manufactured to the same high performance standards as larger Meade models. The DC drive system operates from a micro battery pack for convenient field use. Full accessorization is available for virtually any field application.

Specifications: Model 2045D — Complete with 4″ f/10 Schmidt-Cassegrain tube assembly with super multi-coated optics; fork mount with setting circles, manual slow-motion controls, and locks on both axes; 12-volt DC pulse motor, spur gear drive system; AA battery pack (batteries are not included); tabletop tripod system; eyepiece holder/diagonal prism; coated MA 25mm (40X) eyepiece (1.25″); 5 x 24mm viewfinder. . . . . **$659.**

Packing and shipping in the 48 states . . . . **$40.**

Specifications: 8″ Model 2080A — Complete with 8″ f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls and locks on both axes; 5.75″ worm gear motor drive system (115v./60Hz); eyepiece-holder (1.25″); diagonal prism; coated MA 25mm eyepiece (1.25″); 6 x 30mm viewfinder; equatorial wedge; variable-height all-metal field tripod. . . . . **$1099.**

Model 2080B — Identical to Model 2080A, but in addition with Super Multi-Coated optics. . . . . **$1149.**

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No other comparably-priced Schmidt-Cassegrains offer the optical and mechanical features of the Meade Standard Series:

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☐ **For further information on Meade ED Apochromatic or Schmidt-Cassegrain telescopes, visit one of the hundreds of Meade dealer showroom locations throughout the USA; or contact one of the authorized mail-order dealers at left. Or call Meade Instruments at 714-556-2291.**

☐ *All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

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"Images through the Meade 6" ED/APO are absolutely stunning even by professional standards. Image contrast and definition are amazing. Quality and workmanship are flawless....color correction and contrast are simply better than any telescope I've ever used."
—O. H. Brettman, Past President, The Astronomical League, Huntley, IL

Meade complete ED Apochromatic Refractors include optical tube assembly with giant 2.7" rack-and-pinion focuser, equatorial mount, field tripod, 8 x 50mm viewfinder, giant 2" diagonal mirror, and Super Plössl 26mm eyepiece:

4" f/9 Model 102ED, complete	**$2195.**
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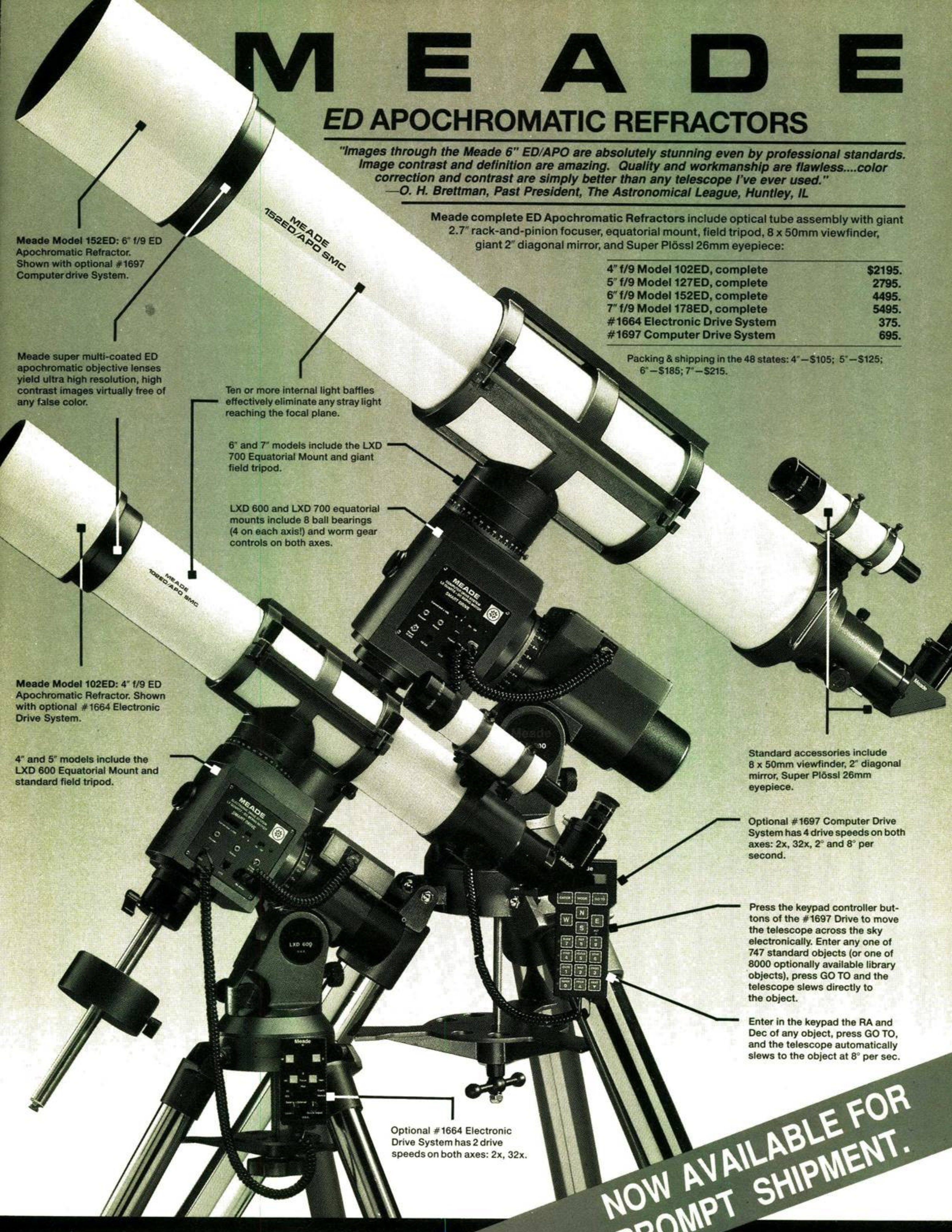
#1664 Electronic Drive System	**375.**
#1697 Computer Drive System	**695.**

Packing & shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



Meade Model 152ED: 6" f/9 ED Apochromatic Refractor. Shown with optional #1697 Computer drive System.

Meade super multi-coated ED apochromatic objective lenses yield ultra high resolution, high contrast images virtually free of any false color.

Ten or more internal light baffles effectively eliminate any stray light reaching the focal plane.

6" and 7" models include the LXD 700 Equatorial Mount and giant field tripod.

LXD 600 and LXD 700 equatorial mounts include 8 ball bearings (4 on each axis!) and worm gear controls on both axes.

Meade Model 102ED: 4" f/9 ED Apochromatic Refractor. Shown with optional #1664 Electronic Drive System.

4" and 5" models include the LXD 600 Equatorial Mount and standard field tripod.

Standard accessories include 8 x 50mm viewfinder, 2" diagonal mirror, Super Plössl 26mm eyepiece.

Optional #1697 Computer Drive System has 4 drive speeds on both axes: 2x, 32x, 2° and 8° per second.

Press the keypad controller buttons of the #1697 Drive to move the telescope across the sky electronically. Enter any one of 747 standard objects (or one of 8000 optionally available library objects), press GO TO and the telescope slews directly to the object.

Enter in the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8° per sec.

Optional #1664 Electronic Drive System has 2 drive speeds on both axes: 2x, 32x.

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Astronomy: Public or Private?

Astronomy Day 1993 highlights a curious dichotomy in our hobby. Is astronomy a public or private experience? On one hand the solitary astronomer crouches over the eyepiece, intently taking careful looks at a distant galaxy. On the other hand children and adults line up in a schoolyard, anxiously awaiting their first glimpse of Saturn.

While most amateur astronomers practice their pastime in quiet anonymity, Astronomy Day should make us shake our mantle of privacy and bring the joy of observing the heavens to the public. Some astronomy clubs exist for the specific purpose of bringing astronomy to the public. Such is the case with the Rose City Astronomers. I suggest strongly to other clubs that they get involved with exciting the public about astronomy as often as possible.

The growth of amateur astronomy means continued and improved service from manufacturers, vendors, and publications like ASTRONOMY. But most importantly, educating the public is the best way to preserve the stars from the onslaught of light pollution.

Astronomy clubs have a duty to inform and educate the public about Earth's greatest natural reservoir of beauty, the universe. — *Bob Duke, publicity director, Rose City Astronomers, Portland, Oregon*

Astrophoto Platform Aid

Telescope makers who want to construct John Iovine's astrophotography platform (November 1992) but find the gimbal somewhat difficult to make have another option. Rather than a gimbal, amateurs can install a wingnut on the drive screw. The wingnut stands in two notches cut with a sharp knife into the bottom board. It's also possible to hold the wingnut in place with a few pieces of hardwood or metal that is glued, nailed, or screwed to the board.

The wingnut allows you to manually rewind the device quickly and continue photographing. — *A. L. Ponjee, St. Augustine Shores, Florida*

No Collision for Uranus?

I want to comment on a story in AstroNews (March 1993) that suggested Uranus experienced a major collision in the recent past. The hypothesis was based on computer models produced by A. Brunini of the Universidad National de La Plata in Argentina and published in *Astronomy and Astrophysics*.

Brunini's suggestion that an impact around the turn of the century changed Uranus' orbit and explains its set of residuals is an interesting one.

However, when a group of us (Neil Tyson, Michael Woodhams, Luca Ciotti and myself) examined his paper closely, we discovered that Brunini underestimated the energetics of such a collision by about twelve orders of magnitude.

Our own calculations, and a consideration of the observational records of the late nineteenth century, lead us to conclude that a collision large enough to alter the orbit of Uranus significantly did not take place. Our paper, "On the possibility of a major impact on Uranus in the past century," has been accepted by *Astronomy and Astrophsyics*. — *Michael Richmond, Princeton University, Princeton, New Jersey*

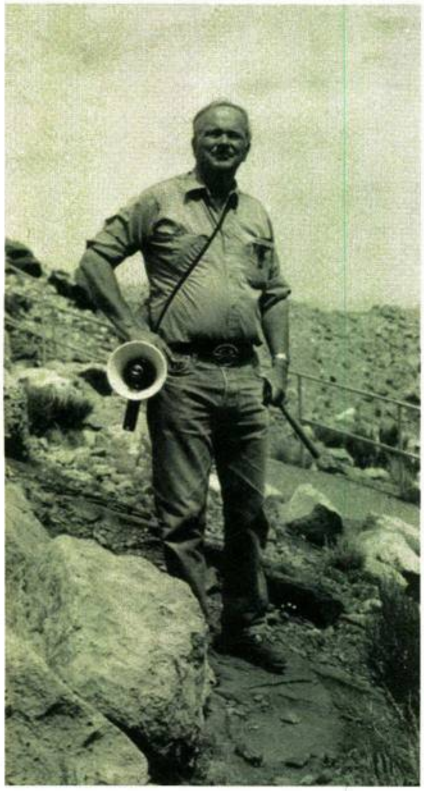
Astro Flashlight

Recently a number of articles have suggested ways to make your own red flashlight for astronomy. I believe I offer the simplest approach yet.

If you have a Mini-Mag Light that uses the bulb with two leads you can do the following: Go to Radio Shack and buy any red LED that has a forward voltage of 2.8 to 3.0 volts. Trim the leads to 1/2" and install the LED as you would the original bulb. I used a somewhat large LED, Radio Shack part number 276-046. I had to remove the flashlight's clear plastic lens, but otherwise the LED is a drop-in replacement for the original bulb. If you plug it in and the LED doesn't work, reverse the LED's leads. — *Dennis D. Datin, Canyon Country, California* □

ASTRONOMY welcomes comments, suggestions, and additional information about articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187-1612. Letters may be edited for length and clarity.

FROM METEOR CRATER TO PALOMAR



Leigh Broadhurst

GENE SHOEMAKER stands inside the Barringer Meteor Crater.

Astronomical Society of the Pacific

CAROLYN SHOEMAKER at the 18-inch Schmidt Camera at Palomar.

Recently Robert Reeves spoke with the husband and wife asteroid hunting team of Carolyn and Eugene Shoemaker. While telling him about their asteroid and comet discoveries, the Shoemakers also revealed how a geologist and a homemaker became highly acclaimed astronomers using instruments atop Palomar Mountain.

Gene Shoemaker

I got a bug in my ear in 1948, shortly after I went to work for the U.S. Geological Survey, that during my professional career human beings would go to the Moon. I made up my mind then that I was going to be the first scientist to get to the Moon.

What could I do as a geologist that related to studying the Moon? I started working on volcanic craters. In the mid-1950s, I seized the opportunity to do the first detailed geological map of the impact-created Meteor Crater in Arizona, because I wanted to understand its structure. I finished the mapping in 1957 and published my first paper about Meteor Crater in 1960. I thought this was going to enable me to stay at the head of the line to be chosen as the first geologist to go to the Moon.

In 1956 I had gone to see the director of the U.S. Geological Survey and explored the idea of starting a program of geological mapping of the Moon. It was clear that soon there would be robotic exploration of the Moon. I expected that manned exploration would soon follow.

With several other geologists, I undertook a lunar geological mapping program using telescopic observations and the best photographs we could lay our hands on. We moved the headquarters of the USGS Astrogeology Branch to Flagstaff. I was then starting to feel more like an astronomer. Our team eventually published a series of maps of the near side of the Moon.

Then, in the early 1960s when the

[continued on page 16]

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TeleVista II 60mm Refractor

Equally at home viewing the rings of Saturn or boats across the bay. Quality 25mm (28x) 1.25"eyepiece, all metal optical tube and yoke mount, finder scope, adjustable tripod, diagonal prism.
#9075 **$199** (8.97)

Sky Explorer II 60mm Refractor

Ideal for lunar and planetary study, plus it's a powerful terrestrial telescope. 900mm f.l, 6x30 finder; star diagonal ; two eyepieces, equatorial mount; setting circles; tripod; and lighted accessory tray.
#9076 **$329** (13.22)

SpaceProbe II 4.5" Reflector

Great 4.5" f/8 reflector, ideal for planetary and deep space. Equatorial mount, slow motion controls, setting circles. 6x30 finder plus 25mm (36x) and 9mm (100x) 1.25" eyepieces. Deluxe tripod.
#9078 **$388** (22.19)

Sky Explorer II 80mm Refractor

Perfect for planetary and lunar observation. Bigger equatorial mount than competitive models, two 1.25" eyepieces, 6x30 finder, star diagonal, deluxe tripod and accessory tray.
#9077 **$488** (32.66)

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Precision Dobsonian-type mounts are the finest in their class. Teflon zero-backlash bearings make it a breeze to track subjects without wobble or vibration. Much more stable than comparable equatorial scopes. Lightweight, rugged, easy to transport and set up. Complete instruction manual.

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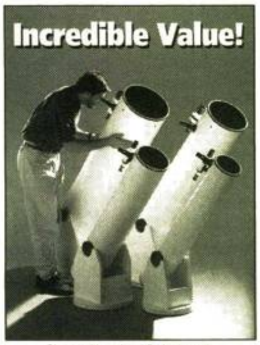


Shown with optional finder scopes

The 6" model is the ideal beginner's or family scope - and is incredibly low-priced. Weighing only 29 lbs. complete, it's easily moved or handled by anyone. The 8" model offers 77% more light grasp, but is still a reasonable 39 lbs. and is only slightly larger.

The 10" and 12.5" models are perfect for those who can observe from darker sky locations. While heavier and larger than the smaller models at 68 and 85 lbs., they offer tremendous performance for their low prices.

Huge Selection of Astronomy Binoculars

New! 50mm Orion Observer™ II Binoculars - 7x, 10x, & 12x

Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, rugged ribbed rubber covering for a good grip. Both have a 7° field of view.

7x50 #9620. **$89.50** (4.44)
10x50 #9623. **$94.50** (4.44)
12x50 #9645. **$94.50** (4.44)

50mm Explorer™ Binoculars

Our newest high performance binoculars with BAK-4 prisms and Multi-Coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design.

7x50 #9306. **$117** (4.44)
10x50 #9308 **$127** (4.44)

50mm Adlerblick Binoculars

Incredible wide field eyepiece design, Fully Multi-Coated, BAK-4 prisms, and best special glass objective lenses make the 7x50 Adlerblick the arch rival of European brand binoculars selling for 3-4 times the price. Orion buys direct, saving you money. Includes deluxe hard case, lens caps and straps.

7x50 #9612, *10x50* #9610 **$287** (5.28)

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7 x 35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 **$147** (4.71)
Rubber Armored Model #9627 **$157** (5.07)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model.

Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501
14X70 #9594 **$299** (6.97)

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable.
#9502 **$379** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended.
#9496 **$389** (8.05)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required.
#9498 **$399** (8.05)

10x70 Military-Spec Binoculars

Light enough to hand hold, yet powerful enough to bring in remarkable views of deep space celestial objects. With military-grade optics, for the highest degree of optical accuracy and mechanical ruggedness. Will last through a lifetime of use, even under the most extreme environmental conditions. Absolutely waterproof and fogproof. With built-in folding rubber objective lens shades/dew caps. Includes deluxe case, photo tripod adapter. 7mm exit pupil. 5° field of view.

#9309 **$444** (7.29)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495, *25x100* #9497 **$888** (17.12)

Observing Aids

NEW! Eyepiece/Accessory Cases

With patented unbreakable latches, die-cut foam inserts.

Inside Dimensions shown
11"x7"x3 #5951 **$17.95** (2.78)
12.5"x9"x5" #5952 **$26.95** (3.36)
16"x11"x5 #5953 **$46.95** (5.19)

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers —fit all Meade & Celestron 8" SCs
DC Model #3503
AC Model #3504 **$44.95** (2.98)

10" Dew Zappers—fit all Meade 10" SCs
DC Model #3506
AC Model #3508 **$49.95** (2.98)

12V DC Dew Gun.—#5601 **$19.95** (2.78)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 **$39.95** (2.98)

Other sizes available for scopes 3.5" to 14" —See our catalog for details

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.lock.

8"Model
#15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43

Ask about other sizes.

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection

Astronomer's Flashlight #5701 **$9.95** (1.79)
Nitewriter Pen #5709 **$8.95** (1.79)
Hands-Free Flex Light #5707 **$17.95** (2.43)
Starlite LED Flashlight #5714 **$24.95** (2.43)
Celestron LED Flashlight #5720 **$19.95** (2.43)

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 **$39.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 **$89.95** (8.02)

Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis. *See catalog.*

Finder Scopes

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White enameled metal tube.

6x30mm — Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12". #13023 **$44.50** (3.41)

6x30mm Right Angle — 90° prism for right-angle viewing. Includes bracket. #13021 **$59.95** (3.41)

NEW! 8x50mm — 2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 **$64.50** (3.41)

NEW! 8x50mm Illuminated—Wireless illuminator with adjustable brightness. #7092 **$94.50** (3.41)

NEW! 9x60mm — 44% more light grasp than 50mm models. #7091 **$99.50** (3.41)

NEW! 9x60mm Illuminated—Wireless illuminator with adjustable brightness. #7093 **$134.50** (3.41)

Mounting Brackets - 2-ring design with non-marring adjusting screws. Fits any scope 6" and over including Celestron & Meade SCs

8x50mm bracket #5040 **$27.95** (2.45)
9x60mm bracket #5041 **$32.95** (2.45)

Rack-and-Pinion Focusers

Finest in their class. Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25" #13007 **$49.95** (2.98)
2.0" includes 1.25" adapter. #13003 **$89.95** (3.95)

NEW! Low-Profile Focusers

Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.

1.25"-#13014 **$39.50** (2.45)
2.0" - #13016 **$59.50** (2.98)

Accessories See Our Catalog for Even More!

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.

1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792

$44.95 ea. (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal
#8763 **$43.95** (2.98)

.965" Star Diagonal
#8761 **$26.95** (2.98)

Hybrid 1.25"/.965" Star Diagonal
#14008 **$31.50** (2.98)

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771
$199 (4.71)

2" Mirror Diagonal–Affordable, high-quality star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$99.95** (3.45)

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$26.95** (2.98)
1.25" #5264 **$29.50** (2.98)
Hybrid 1.25"/.965" #5264 **$29.50** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.

5262 **$38.50** (2.98)

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender #5125 **$27.95** (2.98)
Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.

for SC #5116, *for C-90* #7115 **$26.50** (2.98)

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

Multi-Function Focal Tester

Allows easy, accurate, ultra-sharp focusing, essential for astrophotography.

#7109 **$159** (4.19)

Tripods

Bogen/Velbon/more!
Huge selection of tripods available, for telescopes, spotting scopes and giant binoculars. Choose from assembled models or mix-and-match pan heads and tripod legs, sold separately. See our catalog for details.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7012 **$44.50** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.

#5014 **$15.95 each** (xxx)

StereoScope Viewer

For comfortable two-eyes-open observing. You won't believe the views! Threads securely to the rear cell of your telescope. Requires two identical eyepieces.

#9720 **$479** (5.71)

f/6.3 Reducer/Corrector

Get f/6.3 performance from your f/10 Schmidt-Cassegrain.

#5120 **$169** (3.67)

NEW! Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

Orion's new Sky Wizards are electronic marvels that will put the magic back in your astronomical observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few relaxed hours — without using star charts!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Complete system requires Sky Wizard Model 1 or 2 and a telescope installation package, sold separately.

Encoders and cables available separately for custom installations. Call for details.

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
#7801 **$219** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice.
#7802 **$319** (4.44)

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Celestron Super Polaris	#27100	**$207** (5.29)
Celestron Ultima 8" & 11"	#27101	**$177** (5.29)
Celestron Classic 8" & Powerstar 8"	#27102	**$177** (5.29)
Meade 8" & 10"	#27103	**$202** (5.29)
Dobsonian (fits Coulter and most others)	#27104	**$177** (5.29)

Installation packages available for other telescopes.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.

#5144 **$49.95** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.

#5139 **$119** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.

#17001 **$69.95** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.

#2354 **$109** (8.97)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

Many other sizes available—see our free catalog for details.

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664; 1.25" #5662 **$14.95** (2.43)

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow.
#5510 **$39.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$44.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.
#5517 **$79.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.
#5575 **$119 set** (3.67)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.
#5660 **$54.95** (3.45)

SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes.
#5658 **$79.95** (3.45)

52mm Broadband Filter–For 52mm camera lenses, (Adapter rings available for other diameters.)
#5668 **$74.95** (3.45)

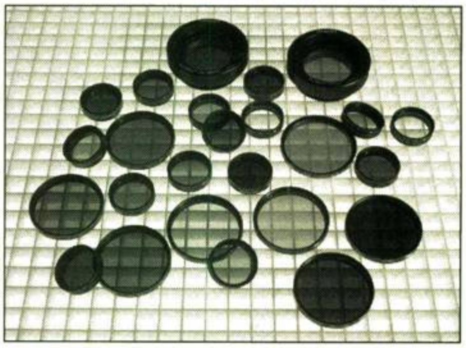
2.0" Broadband Filter–fits 2" eyepieces.
#5659 **$89.95** (3.45)

.965" Broadband Filter–fits .965" eyepieces.
#5661 **$39.95** (2.98)

SkyGlow UltraBlock Filters–Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces.
#5654 **$79.95** (3.45)

SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.
#5656 **$109** (3.67)



Eyepieces & Barlows

✧ Sirius™ Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for 'famous name' Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare themto these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of reflector, refractor and catadioptric telescopes. The Plössl design is renowned for its fantastic performance and has in recent years become the standard by which all other eyepieces are compared.

Each eyepiece is of the classic 4-element Plössl design. Every air-to-glass surface is fully Magnesium Fluoride anti-reflection coated. All lens edges are blackened in the same way as expensive military optics, to further eliminate any scattering of stray light and to maximize contrast.

The optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

We guarantee that you'll be impressed with the performance of the Sirius Plössls, even when compared to the more expensive name-brand Plössls.

25mm #8530, *17mm* #8531, *10mm* #8532, *7.5mm* #8533

Sale! $47.50 each (3.45)

Set of 4 in foam-lined case
#8534 **Sale! $177** (4.71)

Explorer .965" & 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anondized, internally blackened, threaded for filters (except 40mm .965").

.965 Orthoscopic
5mm #8580, 7mm #8581, 9mm #8582, 12.5mm #8583
$49.50 each (3.45)

.965 Kellner
18mm #8584, 25mm #8585
$37.50 each (3.45)

.965 Achromatic Huygenian
40mm #8586
$37.50 (3.45)

1.25" Orthoscopic
5mm #8500, 7mm #8502, 9mm #8504, 12.5mm #8506, 18mm #8524, 25mm #8526
$54.50 each (3.45)

1.25" Kellner
6mm #8536, 9mm #8538, 12mm #8540, 18mm #8508, 25mm #8510, 40mm #8512
$49.50 each (3.45)

Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7-element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element
20mm #8566, 15mm #8568, 10mm #8570, 7.5mm #8572
$74.95 ea. (3.45)

Wide Field 5-element
25mm #8564 **$89.95** (3.45)
30mm #8562 **$94.95** (3.45)
35mm #8560 **$99.95** (3.45)

High Power 7-element *—Long Eye Relief*
5mm #8574, 3.8mm #8576
$84.95 ea. (3.45)

MegaVista 1.25" & 2" Eyepieces

These outstanding eyepieces feature a 7-element design and incredibly sharp, fully multi-coated optics. The long eye relief and integral rubber eyeguards make these ideal for eyeglass wearers. The extra wide field of view (67°-70°) provides stunning images, perfect for deep space observing.

10.5mm 1.25" #8552 **$154** (3.67)
16.8mm 1.25" #8554 **$149** (3.67)
34mm 2" #8587 **$199** (3.67)
40mm 2" #8588 **$229** (3.67)

Illuminated Reticle Eyepieces

Orion offers 4 versions of the illuminated reticle eyepiece, a neccessity for long exposure astrophotography and very useful for polar alignment. All have 1.25" barrels.

12.5mm Plossl Illuminated Reticle
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$109** (3.45)

12mm Kellner Illuminated Reticle
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$79.95** (3.67)

9mm Orthoscopic Illuminated Reticle
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$109** (3.67)

6mm Orthoscopic Illuminated Reticle
Unique adjustable reticle system. Variable brightness. Needs 2 SR-44 batteries, not included.
#8487 **$129** (3.67)

SR-44 Batteries #2360 **2 for $3.49** (3.45)

UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.

#8556 **$159** (3.67)

See our free catalog for a fantastic selection of name-brand eyepieces!

CELESTRON TeleVue

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$34.95** (2.98)
1.25" #8746 **$44.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anondized barrel. 1.25 barrel.
#8750 **$59.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$54.95** (3.45)

Shorty Barlows
The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.

.965" #8710 **$46.95** (3.45)
1.25" #8711 **$54.95** (3.45)

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IN CALIFORNIA: 800-443-1001

IT'S EASY TO ORDER!

- Call Toll-Free and charge to your MasterCard, Visa or Discover Card or send your personal check to order by mail.
- California residents add 7.25% sales tax (8.25% in Santa Clara and Santa Cruz Counties, 8.5% in San Francisco).
- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in (parentheses) after each price. We ship to U.S. and Canada only.
- We expected the prices in this ad to be accurate for May 1993 at the time of our advertising deadline in March. Prices are subject to change or correction without notice.

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#1 for Value

Orion accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!

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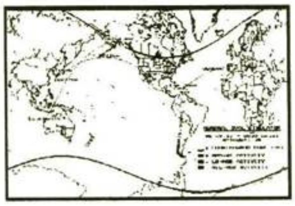

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40x150 EDMT-SX
25x150 EDMT-SX
25x150 EM-SX
(ED glass with 45° viewing)

THE WORLD'S MOST POWERFUL

The most powerful production binoculars on earth are now available with ED low dispersion glass and Fujinon's patented EBC coating. They deliver the ultimate optical performance including high definition, distortion-free images with maximum color correction. Ideal for deep sky studies and comet hunting, the 25x150 and 40x150 models can also bring the horizon within arm's reach during the daytime. Each is equipped with 45° viewing. Built to U.S. Mil Specs, these waterproof binoculars come with a pedestal mount for use on heavy duty tripods or for permanent outdoor installations. The lifetime limited warranty is standard.

25x150 MT-SX also available with straight viewing (not 45°) on special order.

POLARIS
16x70 FMT-SX
10x70 FMT-SX

THE WORLD'S BRIGHTEST

The ultimate in brightness, resolution and optical correction. EBC coating achieves better than 95% light transmission. Flat-field optics reduce distortion and both sagittal and tangential astigmatism to virtually undetectable levels. Providing outstanding balance for comfortable hand held use, each model also offers unprecedented 23mm eye relief (except the 16x70FMT-SX with 12.4mm). Eyepieces with 27mm ocular lenses, are comprised of four groups, five elements. Independently rated best for brightness and clarity, POLARIS models meet U.S. Mil Specs, are waterproof and come with Fujinon's lifetime limited warranty.

Also available, 7x50 FMT-SX

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time came to select the astronaut-scientists for Apollo, I ended up chairing the National Academy of Sciences committee set up to review the qualifications of the applicants. It was a bit of an irony: Instead of being in line to be chosen, I was doing the choosing.

Studying Meteor Crater had led me to think,"How often does a major impact happen and what is the nature of the objects out in space that might hit Earth?" That led me to look into Earth-crossing objects. By 1959, only nine Earth-crossing asteroids had been discovered. It was clear that cataloguing Earth-crossing objects would require years of work.

So in 1969, burned out on the whole lunar business by the intensity of it, I decided to de-orbit from the Moon for a while. I went to Caltech and hired a young geologist named Eleanor Helin. After a couple of years, Eleanor thought she was ready to give asteroid cataloguing a try using the Palomar 18-inch Schmidt telescope. We began an asteroid search program in 1973.

I estimated that there should be about 2,000 Earth-crossing objects as bright as the Apollo asteroid Hermes. Our original game plan was for Eleanor to spend three nights a month on the telescope. I felt that ought to yield about four Earth-approaching asteroids a year — two Apollos and two Amors.

Our idea was to search for trailed images on photographic film. About six months into the program Eleanor discovered a high-inclination Apollo asteroid, 1973 NA. I said, "Hot damn! My estimate was correct!" But then it was two and a half years to the next one. Ultimately, of course, we needed to spend more nights on the telescope. Carolyn entered the observing effort in 1980 and helped develop the stereoscopic technique for searching pairs of films for asteroids. While Carolyn was trying out the stereomicroscope she discovered about 150 unknown asteroids. She has also discovered 27 comets since 1983.

Carolyn Shoemaker

There is no way that I can claim full credit for these discoveries. It's very much a team effort. If others didn't take the films or help with the mechanics that go into it, we couldn't possibly find as many.

My academic background is in history, political science, and English literature. It was never my intent to go into science. In fact, science was not very interesting to me until Gene and I were married. I had intended to be a teacher.

After teaching for one year I decided teaching was not really for me and I concentrated on my family. We have three children, two daughters and a son.

When the children had grown up, Gene suggested a project that needed a little help. It had to do with the discovery of asteroids and near-Earth objects. I got into that work gradually and my interest in astronomy slid in the back door. I found that I enjoyed finding asteroids on the plates taken with the Palomar 18-inch Schmidt. When the stereomicroscope was developed for scanning the films, it was like a new toy. It was like looking at the sky through a window that really put me out there with the stars.

We look at our Palomar films two at a time, side by side on the stereomicroscope. Typically, they are taken 45 minutes to an hour apart. One eye looks at one film and the other eye looks at the other, and the brain happily melds the two into one. This has a wonderful, magical effect: Asteroids and comets appear to float above the flat surface of the stars. At first Gene and I would both look at some films and say, "Does this look like it is floating?" or "Does this look like the real thing?" It was a case of training our eyes and minds to see what we were looking for and to discriminate between real objects and random clumps of grain in the film.

When I found my first near-Earth object in 1983, I was really excited. Here was this little pair of hyphens. I said "Gene, what is this? Oh! It's a near-Earth object!" Then I was hooked.

It was not entirely the asteroids that interested me. I found that the process of searching opened up a whole new world to me because on our films were galaxies and all sorts of beasts in the zoo out there, just many fascinating things. I became quite intrigued with it all.

Then I found my first comet. It was just a pure thrill to see something that I knew instinctively was indeed a comet. I didn't know much about comets and I hadn't yet been hooked on them, but it took only one. I knew I just had to find others. That went hand in glove with looking at things on films, particularly anything that was floating. If it wasn't an asteroid, it was a comet. People wonder if after 27 comets you get the same thrill. All I can say is that every time I find a comet, I have this piercing thrill. I want to dance. I usually go to the staircase and call up to the observers at the telescope and yell, "Yay-y-y-y-y!" And they come racing down to look at it. ☐

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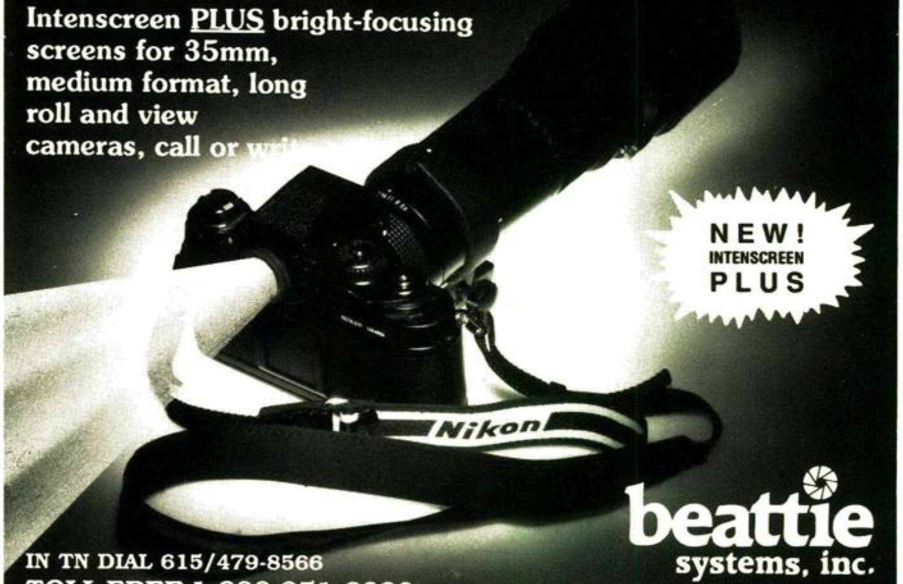

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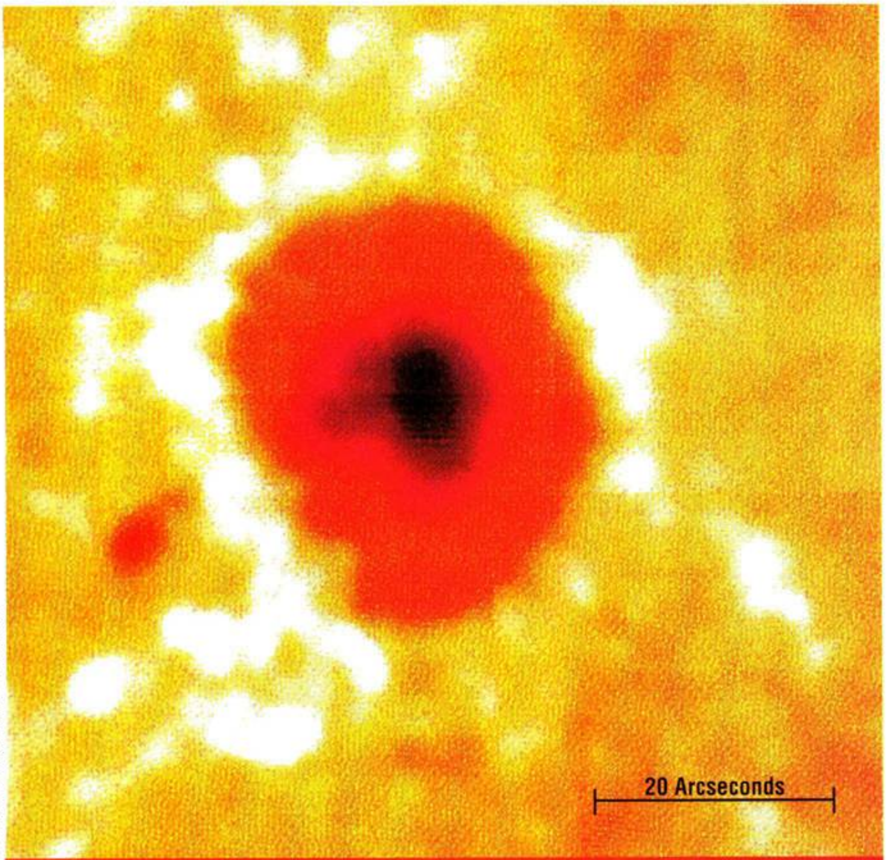
PARALLEL COMPUTER SIMULATES EARLY UNIVERSE

How do you watch the universe evolve over billions of years? By making a model of it in your computer and watching it run in fast forward. That's just what scientists at the Los Alamos National Laboratory did recently using a computer that combines hundreds of processors that are operating simultaneously, a so-called massively parallel computer.

Michael Warren and Wojciech Zurek of Los Alamos, along with John Salmon of Caltech and Peter Quinn of the Australian National University, created a computer model containing 17 million particles representing cold dark matter, a candidate for the invisible but gravitationally strong matter thought to surround and corral visible galaxies. "Since dark matter constitutes the bulk of the mass of the universe, it plays a dominant role in the processes involved in galaxy formation," explains Warren.

To start the simulation, the team arranged the particles to match the expected conditions in the universe when it was very young, including irregularities in the early distribution recently discovered by the COBE satellite. (See "COBE's Big Bang," August 1992.) They then let a fragment of the model universe evolve for the equivalent of 12 billion years, a simulation that required 24 hours of machine time and 400 trillion computations.

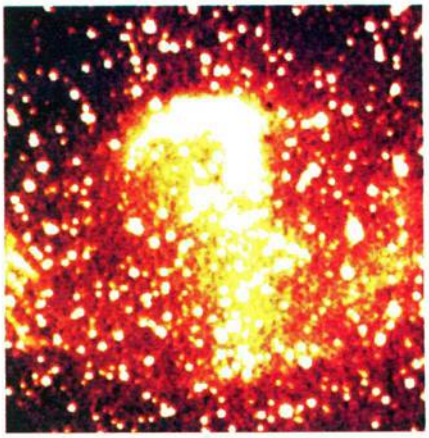
At the end of the simulation, the matter had settled into some 10,000 galaxy haloes across a space of 600 million light-years, about one-thirtieth the diameter of the observable universe. The model universe accurately matched observations of the real universe with one exception — the simulated galaxy haloes were moving several times faster with respect to one another than astronomers observe in real life.



D. Gezari, G. Kopp, and W. Livingston

ASTRONOMERS CAN NOW MEASURE THE SUN'S TEMPERATURE directly using the mid-infrared part of the spectrum. Small temperature differences show up as colors in this false-color image of a sunspot. White is hottest at about 6000 kelvins followed by yellow, red, and black at 5000 K. Previous techniques depended upon theoretical models of the Sun's atmosphere to convert observed intensities to temperatures. But now researchers can determine the temperature directly because the intensity in the mid-infrared is nearly proportional to its temperature.

GIANT NEBULA MAY CONTAIN MISSING LINK



P.N. Appleton/Fick Observatory, Iowa State University

THE BIGGEST AND OLDEST PLANETARY NEBULA yet found appears as wisps of light in this CCD image taken in the green light of doubly ionized oxygen atoms.

It doesn't have a name or even a catalog number yet, but a new object discovered by Iowa State University astronomers appears to be the largest planetary nebula ever found. Steven Kawaler and Phil Appleton, the nebula's discoverers, estimate the expanding cloud of gas to be 17 light-years across and 4,600 light-years away in the constellation Cygnus. In the sky, this translates into an angular size of a whopping 13 arcminutes across, nearly half the diameter of the Full Moon.

The reason such a large object escaped notice until now is that the nebula is faint. To record it, the Iowa astronomers used a 24-inch telescope, an f/4 focal reducer, and 25-minute-long exposures with a wide-field CCD camera. They were led to the object by

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Astronomy 6/93

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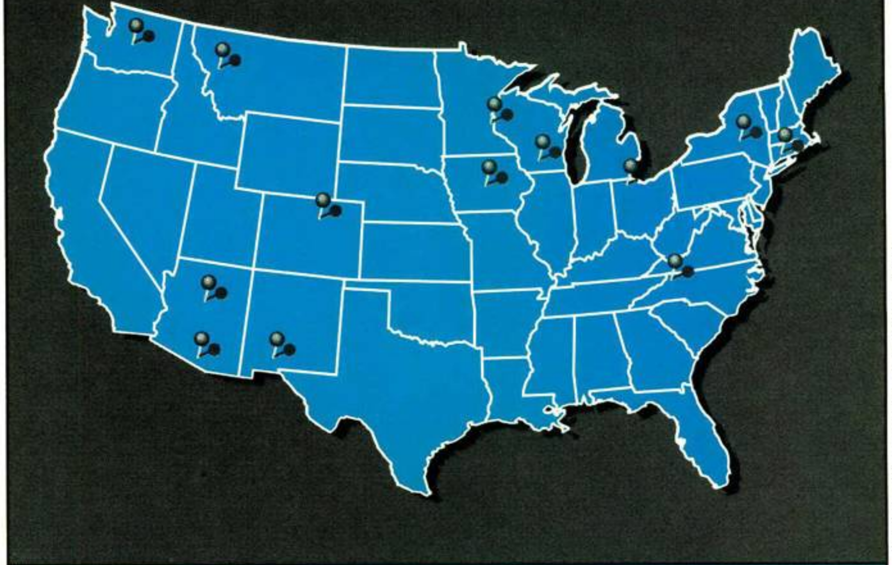
the ROSAT X-ray satellite. One of its X-ray sources, called RXJ 2117+34, turned out to be a faint but hot blue star, making it a good candidate for the central star of a planetary nebula.

The significance of the find is that the nebula's size implies it has been expanding for a long time, perhaps up to 150,000 years, much longer than other planetary nebulae, which are typically only 10,000 to 30,000 years old. A planetary nebula forms when a star the mass of the Sun reaches the end of its normal life. Its nuclear fuel exhausted, the star expands into a red giant and expels its outer layers in a gentle puff. This stellar weight loss exposes a white-hot central star whose radiation illuminates the expanding gas cloud, creating a visible planetary nebula.

According to current models of how stars evolve, the expanding planetary nebula eventually disperses, leaving behind a naked, superhot, compact star called a PG 1159-type star. This star then cools and settles down into a quiet life as a white dwarf, the final stage in the life of most stars in the Galaxy.

This scenario rests on the assumption that PG 1159 stars are the direct descendents of the central stars of planetary nebulae. Until now, no PG 1159 star had been found with any trace of a planetary nebula around it, making for a weak link between planetary nebulae and PG 1159 stars. However, the central star in the newly found nebula appears to have been caught in the act of shedding its nebula and becoming a PG 1159 star. The evidence is that the star exhibits a pulsation rate partway between the long pulsation periods typical of planetary nebula central stars and the fast pulsation periods of PG 1159 stars. If this is its true identity, this missing-link star represents a phase through which our own Sun will pass on its way to becoming a white dwarf some eight billion years from now.

PRESENT SITES IN THE NORTH AMERICAN SMALL TELESCOPE COOPERATIVE



ASTRONOMY: Dave Bruning and Thomas L. Hunt

TELESCOPE COOPERATIVE LOOKING FOR MEMBERS

The North American Small Telescope Cooperative (NASTeC) is looking for college and university members. The purpose of NASTeC is to provide multiwavelength observations of different types such as photometry, spectroscopy, and imaging, and to establish scientific collaborations between large and small astronomy programs. Often the telescopes support space-based observations with the International Ultraviolet Explorer and the Hubble Space Telescope or provide time-critical observations that cannot be made with the limited resources of the national observatories.

Thirteen members (see map above), with telescopes ranging in diameter from 16 to 40 inches, presently form NASTeC. If you are interested in learning more about this cooperative, contact Jason Cardelli, Department of Astronomy, University of Wisconsin, Madison, WI 53706, or phone (608) 262-7921.

CORNING STARTS 8.3-METER MIRROR

Corning Incorporated has begun making the glass for the solid-cast mirror of Japan's National Large Telescope. Construction of the observatory started last July on Mauna Kea in Hawaii with first light through the telescope expected in 1999. The mirror is solid, unlike the 36-segment mirror of the neighboring Keck telescope. But the mirror isn't poured all at one time like the last big mirror, the 5-meter mirror for Palomar Observatory, that Corning made.

The manufacturer starts with silica tetrachloride and titanium tetrachloride. These chemicals react in a furnace at 3100°F, forming a glass vapor that eventually settles on a table that turns slowly in the furnace. After about a week the glass vapor builds up a 5-inch thick disk of glass that is five feet in diameter and has ultra-low-expansion characteristics that are ideal for telescope mirrors.

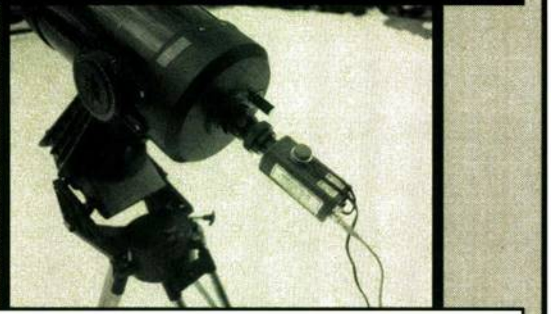
Workers fuse two of the disks together to form a thicker disk and then cut the disk into a hexagonal shape. When 44 hexagons are finished, a furnace 31 feet in diameter will fuse them together. After the mirror cools, workers will remove it from the oven and rework the oven's bottom into a slight mound. The mirror will be reheated in the rebuilt oven to cause the edge to sag 11 inches, creating the concave shape needed to focus light. Corning expects the mirror to be finished by July 1994. Grinding and polishing will require an additional three years.

Glass disks are already in production and the giant furnace is under construction. It should get another round of use for the mirrors for the Gemini Project 8-meter telescopes. Construction for the first Gemini scope is expected to start this summer on Mauna Kea.

WHY DO STARS BLOW APART?

Nature seems to explode stars with ease, yet astronomers have for years had trouble understanding what triggers supernova explosions. The key is understanding what happens during the split

ASTRO VIDEO CAMERA



Capture the sky on videocassette with this new system from Roger W. Tuthill.

The Astro Video Camera weighs 16 ounces, measures 5 by 2 by 2 inches, and has a standard C-thread mount (an optional T-to-C adapter is available). With an 8-inch telescope, the camera allows real-time, monochromatic recording of stars as faint as 9th magnitude. A 510-by-492-pixel detector images about the same field of view as a 7-mm eyepiece, making high-resolution planetary work particularly suitable. Features include automatic gain adjustment and eight electronic shutter settings. A television, computer monitor or TV-VCR combination can be used to view the camera's output. An AC power adapter is supplied.

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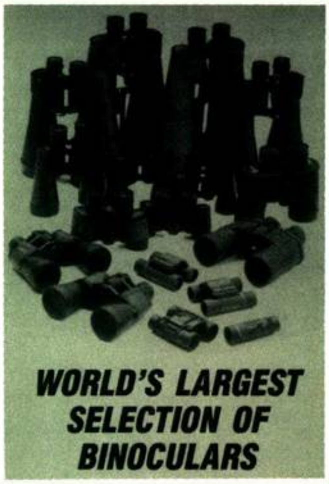

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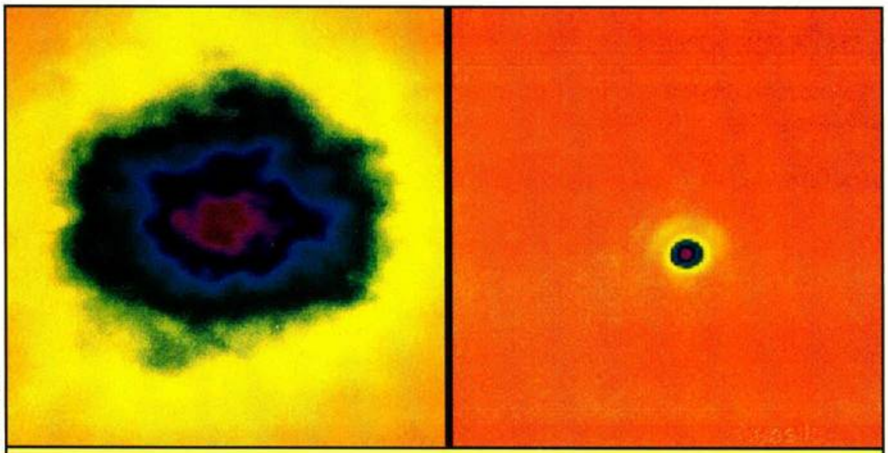


USAF/DOD

RAZOR-SHARP IMAGES result from the latest in adaptive optics technology, which improves telescope performance by correcting for turbulence in Earth's atmosphere. The standard image of the bright star Capella (left) appears like an unsharp blob compared with the adaptive optics image made with the same instrument (right). The shots were made with the 1.5-meter telescope at the Starfire Optical Range at Kirtland Air Force Base, New Mexico.

second between the collapse of a massive star's core to neutron star densities and the explosion of its outer layers as a supernova. Astronomers have fashioned intricate computer models to simulate the event, only to watch the simulated supernova explosions fizzle as duds.

Now a new study shows how stellar material falling onto the neutron star formed at the heart of a supernova can release a fireball of neutrinos, subatomic particles that carry energy but have little or no mass. Willy Benz of the University of Arizona, Stirling Colgate of Los Alamos National Laboratory, and Marc Herant of the University of California, Santa Cruz, developed the neutrino fireball model to explain how the atmosphere of a collapsing star heats up enough to create a dramatic explosion.

Most of the neutrinos released from the collapsing core escape into space without delay. But a significant fraction are absorbed by and heat the gases near the surface of the neutron star core, causing those gases to rise as buoyant plumes. As the hot gases rise, they are

Space News

JAPAN SETS SIGHTS ON MOON AND MARS

The late 1990s could see Japan launch a probe to the Moon and another to the planet Mars. The Moon mission, called Lunar-A, follows the Japanese Hiten mission launched in 1990 that released a sub-satellite into orbit about the Moon, the first spacecraft to visit our neighbor world in 14 years.

Lunar-A is an ambitious project. If all goes according to plan, early in 1996 the craft will fire three penetrators into the lunar surface. Each probe will pierce the Moon's surface at over 650 miles per hour, carrying instruments 3 to 10 feet into the lunar soil. The penetrators will each carry a seismometer for detecting moonquakes and a heat probe for taking the Moon's temperature. The goal of Lunar-A is to learn more about the Moon's interior.

The Mars probe, called Planet-B, is scheduled for launch in 1996 and will orbit Mars as close as 150 miles above the surface. It will have a camera for studying Martian weather and surface features and instruments for exploring the upper atmosphere and its interaction with the solar wind.

Beyond these two missions, the Japanese agency that looks after scientific satellites, the Institute of Space and Astronautical Science (ISAS), is studying plans for a Venus balloon probe, a comet coma sample-return mission, an asteroid rendezvous craft, a Mars penetrator, and a Mars minirover. ISAS may also participate in NASA's upcoming Mars Environmental Survey Mission (MESUR), a series of probes with launches beginning in 1996 that is part of NASA's Discovery program.

JAPANESE X-RAY SATELLITE LAUNCHED

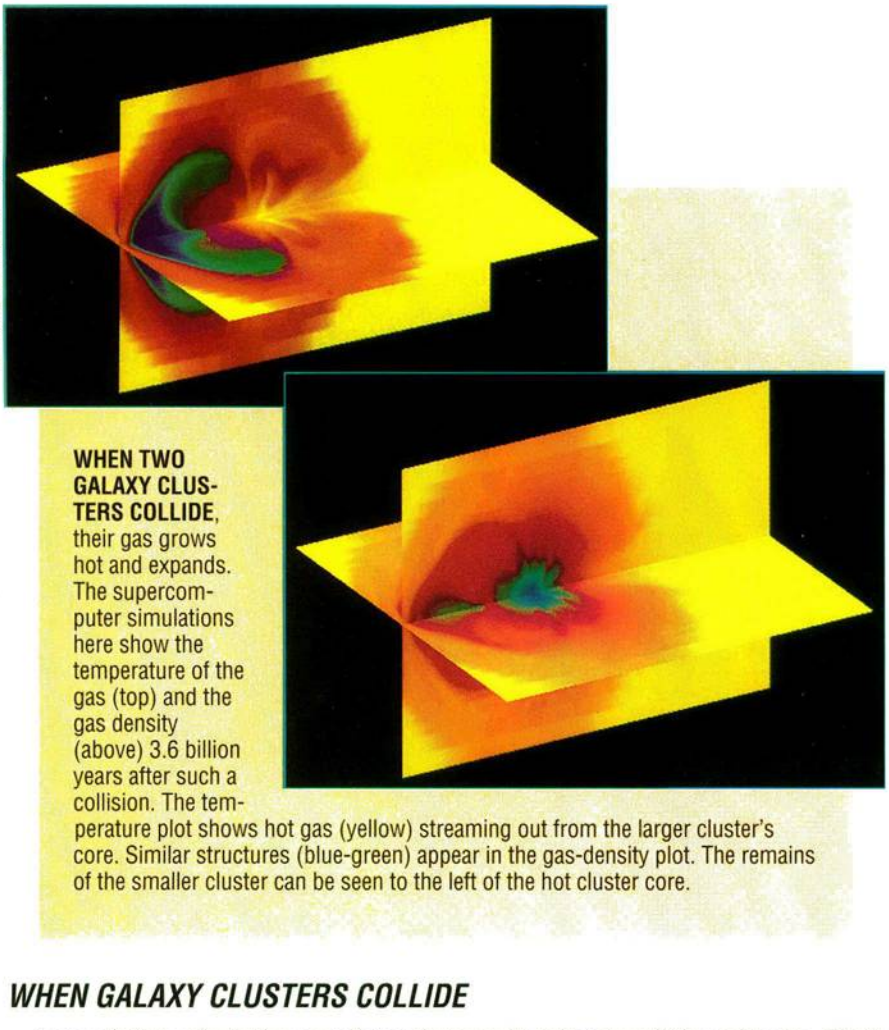
On February 20, a Japanese-built M-3 rocket roared from the launch pad at the Kagoshima Space Center in Japan. Its payload was a new X-ray astronomy satellite originally called Astro-D but now renamed ASCA, the Advanced Satellite for Cosmology and Astrophysics. (The Japanese characters for ASCA also mean "flying bird.") ASCA is now circling Earth in a 523 by 615 kilometer orbit. Its mission is to explore the X-ray sky in the low-energy band of the X-ray spectrum.

The satellite's instrument combines the X-ray gathering technology used in the Broad Band X-ray Telescope flown on the Shuttle-based Astro-1 mission in December 1990 (see "Astro's Violet Universe," May 1991) with the detector technology planned for the Advanced X-ray Astrophysics Facility satellites set for launch in 1999. During its mission, ASCA will point at up to six targets per day, measuring the strength and wavelengths of X rays coming from objects such as supernova remnants, neutron stars, black holes, galactic cores, and clusters of galaxies.

ASCA is a joint mission of Japan's Institute of Space and Astronautical Science and NASA. Sixty percent of the observing time will go to Japanese investigators, 15 percent to American scientists, and 25 percent for collaborative Japanese-U.S. experiments.

replaced by cooler gases dragged down by the neutron star's gravity. When the falling gases hit the neutron star, they splash across its surface and heat up. The hot gases break apart into free particles and release more neutrinos that heat the gases still further, releasing still more neutrinos. The chain reaction creates a neutrino fireball that explosively heats the gases surrounding the core and sends them rocketing skyward, pushing the overlying atmosphere into space as they go. The entire process takes only a few seconds.

The bubbles of rising gas can also give a powerful kick to the supernova's core, ejecting it across space at high speed. Astronomers have observed such fast-moving neutron stars and may now know what propelled them into motion.



K. Roettiger, et al., New Mexico State University

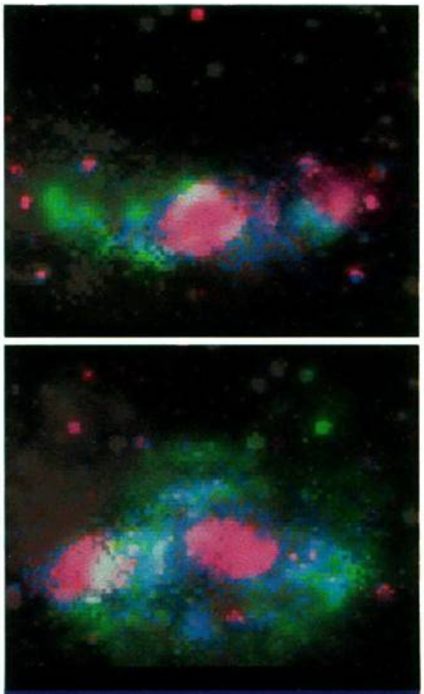
WHEN TWO GALAXY CLUSTERS COLLIDE, their gas grows hot and expands. The supercomputer simulations here show the temperature of the gas (top) and the gas density (above) 3.6 billion years after such a collision. The temperature plot shows hot gas (yellow) streaming out from the larger cluster's core. Similar structures (blue-green) appear in the gas-density plot. The remains of the smaller cluster can be seen to the left of the hot cluster core.

WHEN GALAXY CLUSTERS COLLIDE

Large clusters of galaxies may form when smaller clusters collide and merge. That's one conclusion supported by new supercomputer models that simulate such collisions.

New Mexico State University astronomers Kurt Roettiger, Chris Loken, and Jack Burns developed the computer program to learn what happens when galaxy clusters collide. They took two clusters of different sizes, started them at rest, and let gravity bring on the collision. They then looked at the evolution of the clusters' gas and dark matter, the unseen material that makes up roughly 90 percent of a typical cluster's mass.

The group found that shock waves produced in the collision dramatically heated the gas and caused the larger cluster's core to expand. Meanwhile, the gravity of the larger cluster ripped away the dark matter of the smaller cluster, capturing some of it and scattering the rest into intergalactic space. The capturing of some dark matter shows that large galaxy clusters could form and grow through the collision and merger of many smaller clusters.



Ohio State University and the National Radio Astronomy Observatory

COLLISIONS MAY CREATE SOME DWARF GALAXIES. The collision between IC 2163 (galaxy at left in both images) and NGC 2207 formed giant hydrogen gas clouds, each containing 100 million times the Sun's mass. The clouds are 10 times more massive than the largest hydrogen clouds in our Milky Way Galaxy. Several of these gas clouds may eventually escape from their parent galaxies to become an isolated small galaxy.

Red and blue in these pictures correspond to their actual visible light colors. Radio observations shown in green reveal the location of hydrogen gas. The top picture shows only the hydrogen gas in IC 2163; the bottom picture shows the gas in NGC 2207. At least 10 giant gas clouds have formed since the collision between the two galaxies 100 million years ago.

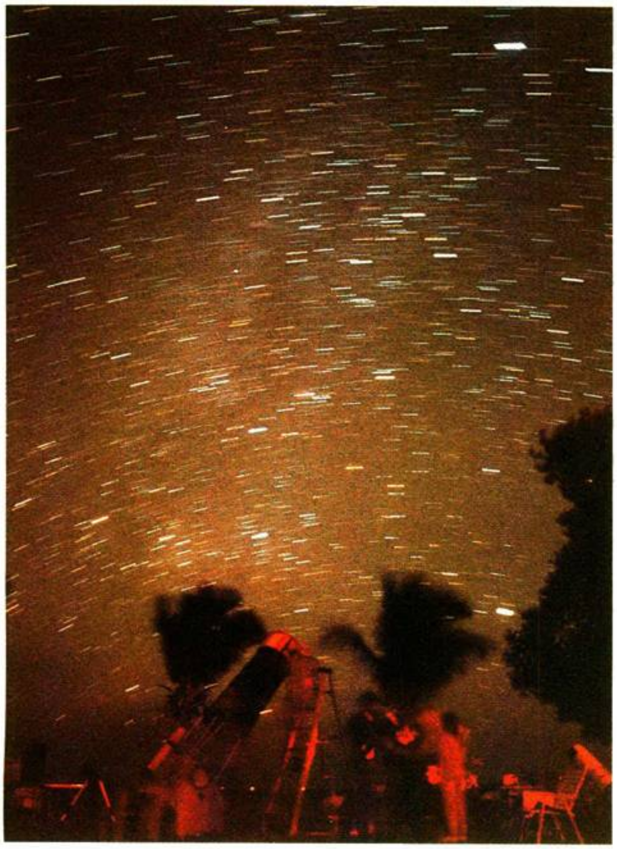
Bruce Elmegreen of IBM's research division, Michelle Kaufman of Ohio State University, and Magnus Thomasson of the Nordic Institute for Theoretical Physics in Copenhagen, Denmark, reported their results at the January meeting of the American Astronomical Society.

Amateur News

GET YOUR LATITUDE ADJUSTED

Skies clear and dark, warm temperatures, and a low latitude — who needs more for delightful observing? That was the story for the 600 attendees of this year's Winter Star Party, held February 15 to 21. The WSP is organized by Miami's Southern Cross Astronomical Society, with chairman Bob Ward, registrars Bob and Sharon Grant, master of ceremonies Tippy D'Auria, and dozens of volunteers helping to make it a success.

The meeting is held at Camp Wesumkee on West Summerland Key, one of the small islets that U.S. Route 1 crosses on its meandering way to Key West, Florida. The site boasts a latitude of 24.6° north, low enough to give telescopic views of the Southern Cross, Alpha Centauri, the Eta Carinae nebula, globular cluster Omega Centauri, and radio galaxy Centaurus A — to name a few splendid objects that rank as tropical exotics to northern astronomers.



ASTRONOMY: Robert Burnham

BIG SCOPES, WINTER STARS, AND PALM TREES mingle at the Winter Star Party, held in the Florida Keys every February.

Each day the campgrounds stayed quiet until late morning as observers slept. In the afternoon, programs of speakers discussed topics such as making drawings at the eyepiece, CCD astrophotography, searching for extraterrestrial intelligence, and the dinosaur-dooming asteroid impact in the Yucatan. Displays of new equipment by vendors, a mirror-grinding workshop, and swap tables kept everyone busy until dinner.

At nightfall, Orion and the whole winter Milky Way stood high over the ocean, and the skies were every bit as gorgeous as you'd imagine. Venus was a beacon in the west, with Mercury far below it. Murmured voices and laughter carried as people opened scopes and unpacked eyepieces by red flashlight.

Many spent the whole night observing. I saw familiar galaxies, clusters, and nebulae — many better than at home in Wisconsin because they were higher in the sky. The Orion Nebula in Tom Clark's Yard Telescope (a 36-inch f/5 Dobsonian reflector) was a luminous blue-green grotto softly lit with pinpoint blue-white stars. Perched atop a 15-foot ladder, I got the most spellbinding view I've ever had of this object. I literally could have stared at it all night.

Another hit for me was Eta Carinae, low in the south. This cluster-and-nebula would be unbelievably spectacular if we could see it as well as Orion. I traced the three dust lanes as they threaded between stars and glowing gas. A little later, I saw Alpha Centauri A and B, another personal first.

Other memories: Leaning on a palm tree to steady my 7x50s as I scanned Coma and Virgo. Or the camaraderie of the dark, when you have long talks about astronomy with people at 3 a.m. — but have no idea what they look like!

Finally, as the wee hours creep by, you realize the glow in the east isn't the lights of Marathon a dozen miles away. It's the summer Milky Way coming up. A glance south confirms it: There's Scorpius, its crooked hook dangling over the sea, with the Teapot of Sagittarius right below.

It'll be months yet before I view those sights again from home, but their presence at the end of a long winter's night points reassuringly toward summer skies to come. — *Robert Burnham*

WORKSHOPS HIGHLIGHT ALCON '93

Amateur astronomers from around the United States will converge on Madison, Wisconsin, this summer for ALCON '93, the national convention of the Astronomical League. From July 29 to 31 amateurs will participate in workshops and astrophotography contests and take in exhibits and lectures. The theme of this year's meeting is Astronomy from Earth and Space with special guest lectures from Roberta Humphreys of the University of Minnesota and Arthur Code of the University of Wisconsin.

A highlight of ALCON '93 will be a series of instructional "how-to" workshops on CCD imaging, lunar and planetary observing, astrophotography, video astronomy, deep-sky observing, occultations, and conducting variable star programs. Workshop leaders include Richard Berry, Mark Coco, David Darling, Dave Eicher, Dan Joyce, Bob Manske, Don Parker, Jeff Peronto, Gerry Samolyk, Bert Stevens, Dan Troiani, and David Weier.

ALCON will also offer tours of the historic Washburn Observatory, the Yerkes Observatory (home of the world's largest refractor telescope), and the Space Astronomy Lab at the University of Wisconsin. The meeting site is the Sheraton Inn and Convention Center in Madison. For more information or to register, contact the Madison Astronomical Society, ALCON '93, P.O. Box 14747, Madison, WI 53714-0747. The deadline for signing up for tours is June 10. ☐

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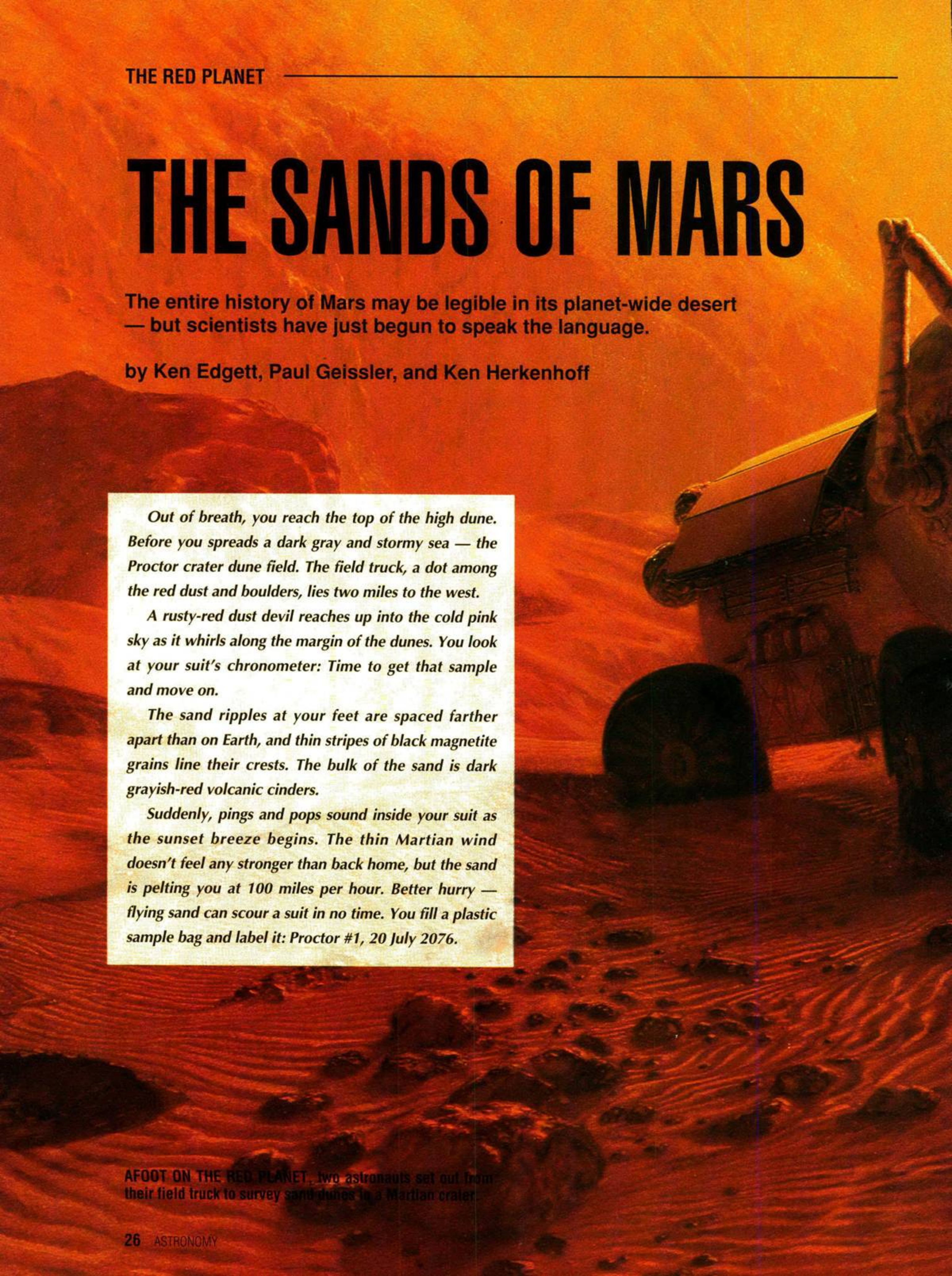
THE SANDS OF MARS

The entire history of Mars may be legible in its planet-wide desert — but scientists have just begun to speak the language.

by Ken Edgett, Paul Geissler, and Ken Herkenhoff



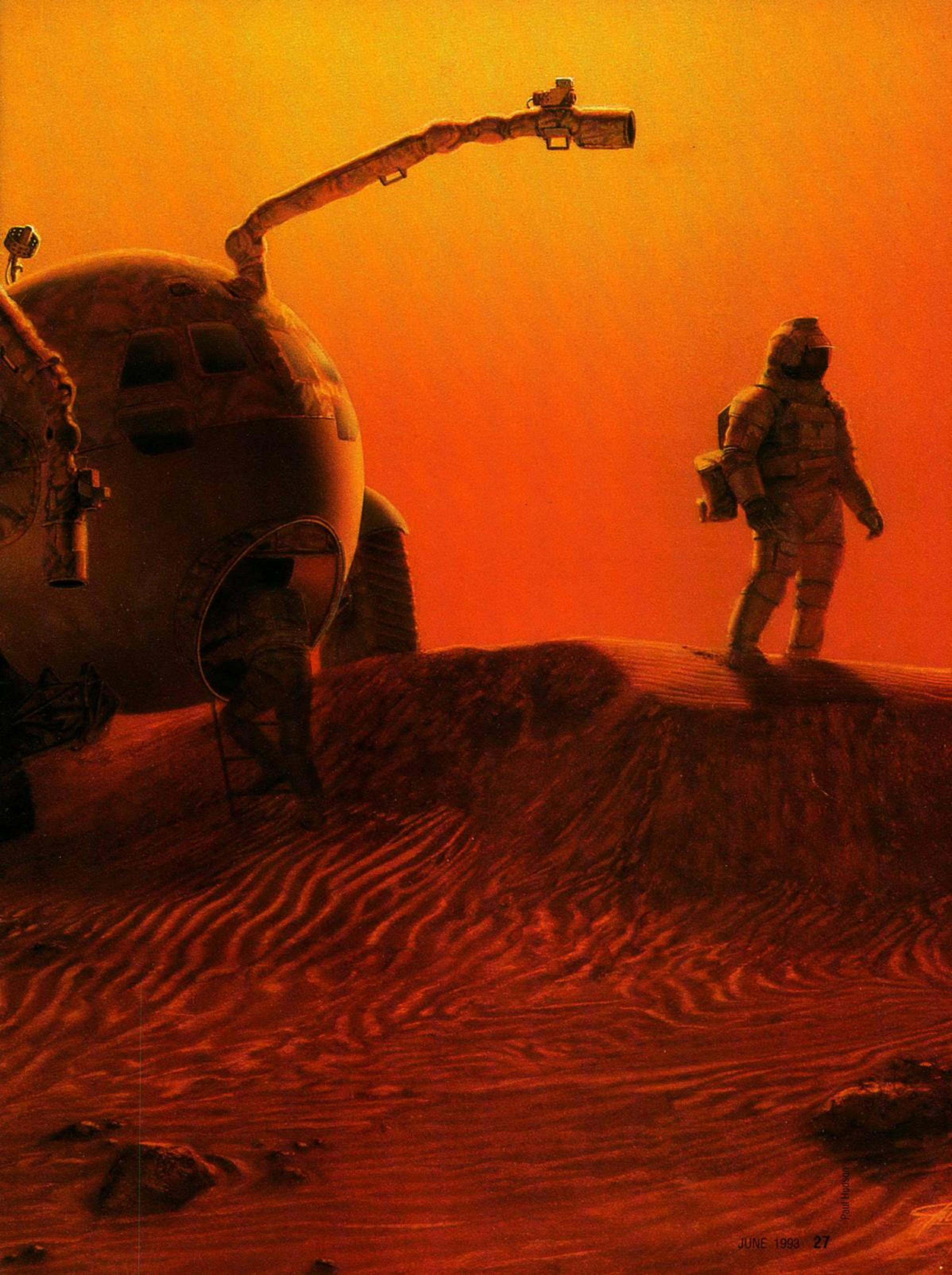
Out of breath, you reach the top of the high dune. Before you spreads a dark gray and stormy sea — the Proctor crater dune field. The field truck, a dot among the red dust and boulders, lies two miles to the west.

A rusty-red dust devil reaches up into the cold pink sky as it whirls along the margin of the dunes. You look at your suit's chronometer: Time to get that sample and move on.

The sand ripples at your feet are spaced farther apart than on Earth, and thin stripes of black magnetite grains line their crests. The bulk of the sand is dark grayish-red volcanic cinders.

Suddenly, pings and pops sound inside your suit as the sunset breeze begins. The thin Martian wind doesn't feel any stronger than back home, but the sand is pelting you at 100 miles per hour. Better hurry — flying sand can scour a suit in no time. You fill a plastic sample bag and label it: Proctor #1, 20 July 2076.

AFOOT ON THE RED PLANET, two astronauts set out from their field truck to survey sand dunes in a Martian crater.



Paul Hudson

For over three centuries, astronomers have peered across tens of millions of miles of space to gaze upon a vast cold desert with light and dark markings. Once believed to be vegetation, the seasonally variable markings on Mars actually result from the shifting of wind-blown sand and dust across the planet's surface.

Dust and sand suggest forbidding wastes, but to planetary scientists the sands of Mars offer the promise of understanding much about the planet, in particular its climate. The location of dunes, for example, can provide clues to seasonal wind patterns. On Earth, much sand comes from debris tumbling along the bottoms of rivers and coasts beaten by ocean waves. Likewise Martian sand may come from the giant flood channels carved into the face of this ancient planet. Did ocean waves once break upon sandy Martian shores? What can the minerals in the sands tell about weathering on this arid planet? Finally, will Martian sands have any practical or economic value to future astronauts or even residents of the Red Planet?

Such questions have tantalized planetary geologists for decades. In August the Mars Observer spacecraft will reach the planet (see "Return to the Red Planet," ASTRONOMY, September 1992). The spacecraft will not land, but from orbit its extremely high-resolution pictures of the surface will help scientists learn more about dunes and dust and their behavior under Martian conditions. It will also provide detailed data about the mineralogy of Martian sediments.

Whatever they are made of, Martian sand dunes aren't like most of the ones here on Earth.

Billion-Year Dust Bowl

Deserts *are* Mars. This is a planet-wide desert with as much area as all of Earth's dry land put together. For eons, icy winds have etched its face — eroding, depositing, and moving loose sediments around. Movies have taught us that deserts mean dunes, but actually dunes are rare on both planets. On Earth, dunes cover about 5 percent of the land, while less than 1 percent of Mars has dunes large enough to show in spacecraft images. The relative scarcity of dunes is a clue for scientists studying the ebb and flow of Martian sediments. If dunes are harder to find on Mars than on Earth, this may mean that Martian bedrock breaks down more slowly or perhaps that sand grains don't survive as long in the Martian environment.

While true sand appears fairly rare on Mars, dust grains — particles less than $^{1}/_{50}$ mm in diameter — are far more widespread, thanks to the winds. Dust is picked up in suspension and carried all around the planet. It then falls out in a thin coating over rocks and dunes alike whenever the wind grows still. Wind-blown sand behaves differently, as anyone knows who's stood barelegged on a windy beach. Sand grains hop and bounce along the surface, flying up to sting your legs — or they roll along, slowly burying your feet in ripples and drifts.

Mars is no different, except for one important change. Because the air is so thin, a wind that moves sand on Mars is blowing about 10 times stronger than one on Earth. If you were standing in it, the wind might not feel any different than a good breeze here. Yet your spacesuit would soon show the effects because the wind-blown particles would be moving at over 100 miles per hour.

Dune Planet?

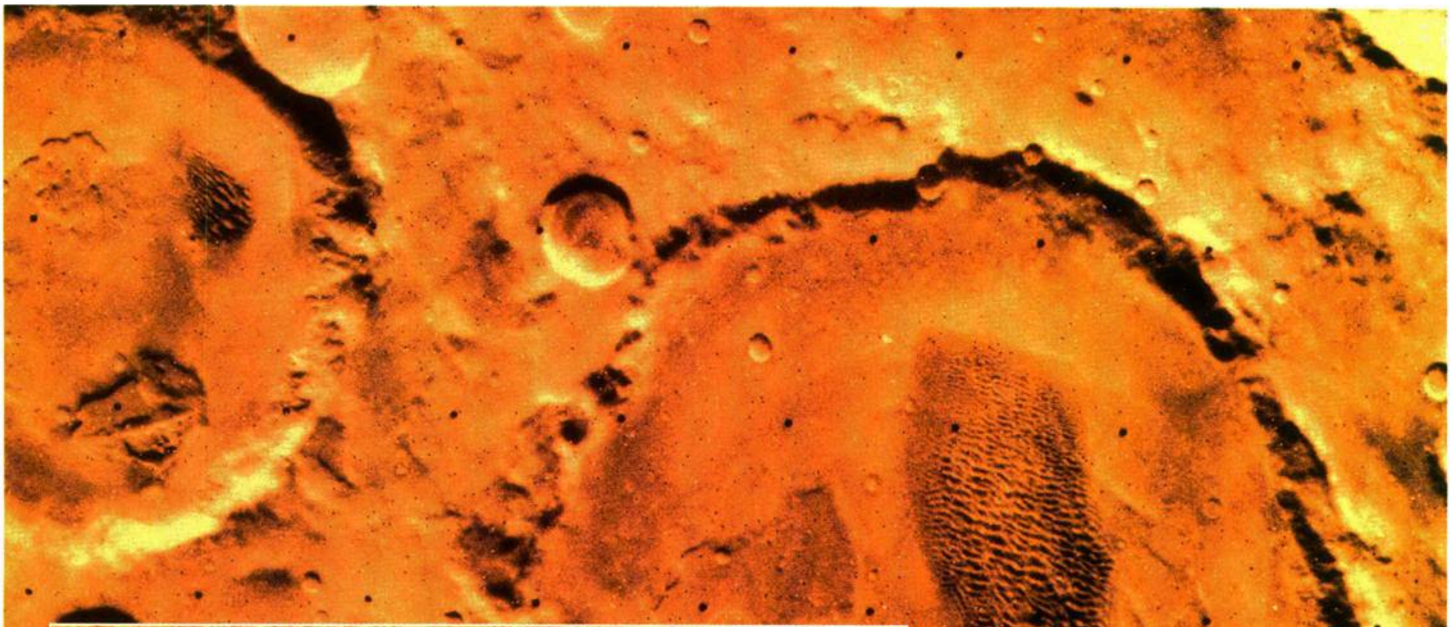
Perversely, the comparative lack of dune fields on Mars is helping planetary scientists study where the sand comes from. But as we'll see, the scarcity also embodies at least one mystery. Images from the Mariner and Viking spacecraft show the biggest concentration of dunes on Mars is a huge, Sahara-sized sand sea surrounding the north polar ice cap between latitudes 75° and 85° north. A second sizable group of dunes occurs near the south polar cap, especially between 55° and 75° south. But unlike the north polar dunes, those at high southern latitudes do not form a continuous sand sea; they cover only crater floors and other low areas.

A third major group of dunes lies in Hellespontus, west of Hellas Basin in an area 40° to 55° south. The Hellespontus dunes were among the first identified because they are large enough to show in pictures with moderate resolution. Elsewhere on the planet lie smaller dune fields, perhaps containing less sediment and certainly requiring higher image resolutions to be studied. Small dunes are common on floors of craters in the Oxia region, northeast of Valles Marineris, and still other geologically significant dune fields lie in Valles Marineris and Syrtis Major.

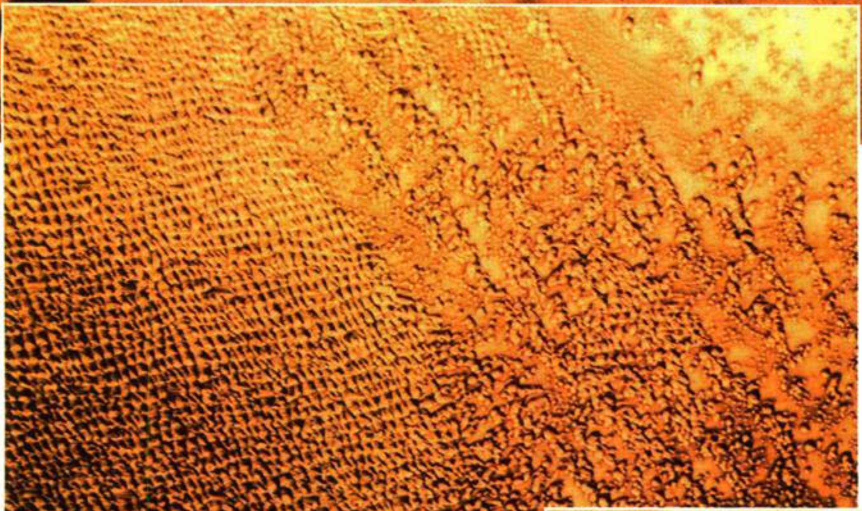
Martian sand dunes differ from terrestrial ones in color and probably in composition. Mars dunes are *dark*, unlike the white, tan, or pink ones on Earth. Most Earth dunes are quartz sand. Quartz is a common, durable white or transparent mineral of the continental crust. It resists Earth's chemical assault and can survive as sand-sized grains for more than a billion years. Quartz grains from beaches 3 or 4 billion years old are still around today. Ancient quartz particles have eroded out of sandstones and been reworked into new dunes, beaches, and sandstones many times over.

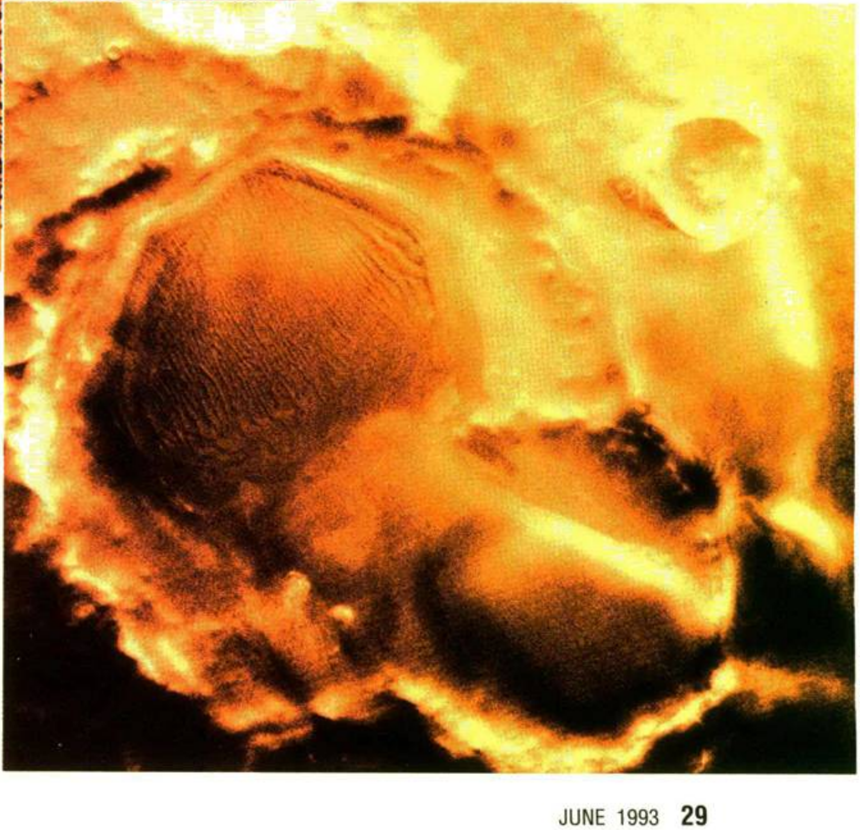
Other dunes on Earth are made of evaporites, carbonates, or dust aggregates. These "sands" are less durable, and all of them occur only in special terrestrial environments. They are likely to be even more scarce on Mars, where the required conditions either didn't exist or were much less common.

The few dark dunes on Earth come mostly from volcanic rock fragments, ash, or cinders. Some are gray; others are nearly black. Being largely basalt, a dark volcanic rock, they contain lots of magnesium and iron minerals. As with old cast-iron cook pots, unoxidized iron makes basalt look black. Dark basaltic dunes are found in Iceland, Hawaii, and Washington State. Basalt sands are rare on Earth because their minerals weather easily, typically surviving less than 20,000 years. Scientists believe that if terrestrial basalt dunes are dark



LOOKING LIKE A GEOLOGICAL THUMBPRINT, the dune field in Proctor crater, 60 km long, may contain deposits of water ice.





A VAST SEA OF SAND DUNES, Mars' north polar desert (above) poses mysteries for scientists seeking its origin. The dunes in Richardson crater (right) lie adjacent to the edge of the south polar ice cap, seen at lower right.

All photos NASA/JPL

VISIBLE IN THE EARLIEST SKETCHES of Mars, Syrtis Major is a broad region of lava flows around a shield volcano. The sand that covers it probably derives from cinders and ash.

and Martian dunes are also, then Mars' dunes are probably basaltic.

Dust also tells a story. Martian dust differs from Martian sand in color, reflectivity, and again probably in mineralogy. Typical dust deposits reflect 20 to 40 percent of the sunlight that falls on them, while dunes reflect only about 5 to 15 percent. Dust deposits tend to be bright rusty-red, unlike the black, or dark grayish-red, sand dunes. The Viking landers analyzed Martian soil for its chemical makeup. They found that even though separated by thousands of miles, the soils at both lander sites were chemically identical. This "soil" is actually a dust that appears to be extremely weathered and chemically altered basalt, probably material deposited by passing dust storms. Viking data suggest Mars soils have much the same chemistry because global dust storms have made a homogeneous mix of the planet's dust-sized debris.

This leaves the makeup of dunes unexplored. Unfortunately, the drifts at the Viking 1 site lay out of reach of the lander's sampling arm, so scientists aren't sure if these drifts are sand grains or aggregates of dust. For now, the only way to study the mineralogy of dunes is with remote observations from Earth or from Mars orbit. This means that scientists have to focus mainly on the largest features, such as the vast dark region Syrtis Major (see photo at left), familiar to every telescopic observer.

Syrtis Major has persisted for centuries — indeed, it appears in the first sketches of Mars, made by Christiaan Huygens in 1659. In 1978, the Viking 1 orbiter took a high-resolution photo showing that at least part of Syrtis Major's surface is made up of dark dunes. The rest of Syrtis Major may also be covered by wind-blown sand, but it isn't necessarily piled up into dunes. However, Syrtis Major is more than just a big dark sandy patch. Viking images also revealed that Syrtis Major's bedrock consists of a low shield volcano, with two volcanic calderas near the center. This volcano is probably basaltic like other shield volcanos on both Earth and Mars. Indeed, spectroscopic observations of Syrtis Major revealed unoxidized iron typical of basalt and suggested the presence of pyroxene, a common basalt mineral.

Yet for rock to become sand there has to be erosion, either by wind or water. As yet no evidence — such as dry water channels or eroded ridges — exists to show that Syrtis Major's lava flows have been eroded to form the basaltic sand that covers much of the region. Instead, the sands might be volcanic ash and cinders erupted ages ago from the Syrtis volcano. Volcanic sands don't last long on Earth, but assuming that chemical weathering operates more slowly on Mars, these cinders could well be quite old. This would remove the need to suppose that Syrtis had erupted recently (for which there is no evidence).

The dunes outside of Syrtis Major are more problematic. Scientists think it's safe to eliminate quartz, evaporites, and carbonates as sources. Quartz requires a degree of geological evolution that Earth had (thanks to plate tectonics) but which Mars never attained. Evaporites and carbonates probably formed on Mars, but only in small quantities. These light-hued materials cannot be dominant in Martian dunes. Once again, dark-hued basaltic grains seem most likely. These materials may be fragments of lava or crystalline bedrock, volcanic cinders, bits of volcanic glass, or iron- and magnesium-silicate grains.

Scientists know of at least two more dark-hued sand fields that lie near a basaltic source and support a volcanic origin. One is the vast Valles Marineris rift system, where dunes on the canyon floor appear to have eroded from massive dark-hued ash deposits in the canyon walls (see photo on pages 32-33). Some of the dark material may have formed by volcanic eruptions within the Valles Marineris canyons, while others may have come from the giant Tharsis volcanos to the west. A second example is the prominent dark feature known as Cerberus, lying just south of the Elysium volcanic region. This too might represent a wind-worked basaltic sand deposit.

If Earth's major deserts are in the tropics, why do Mars' biggest dune fields lie in its polar regions?

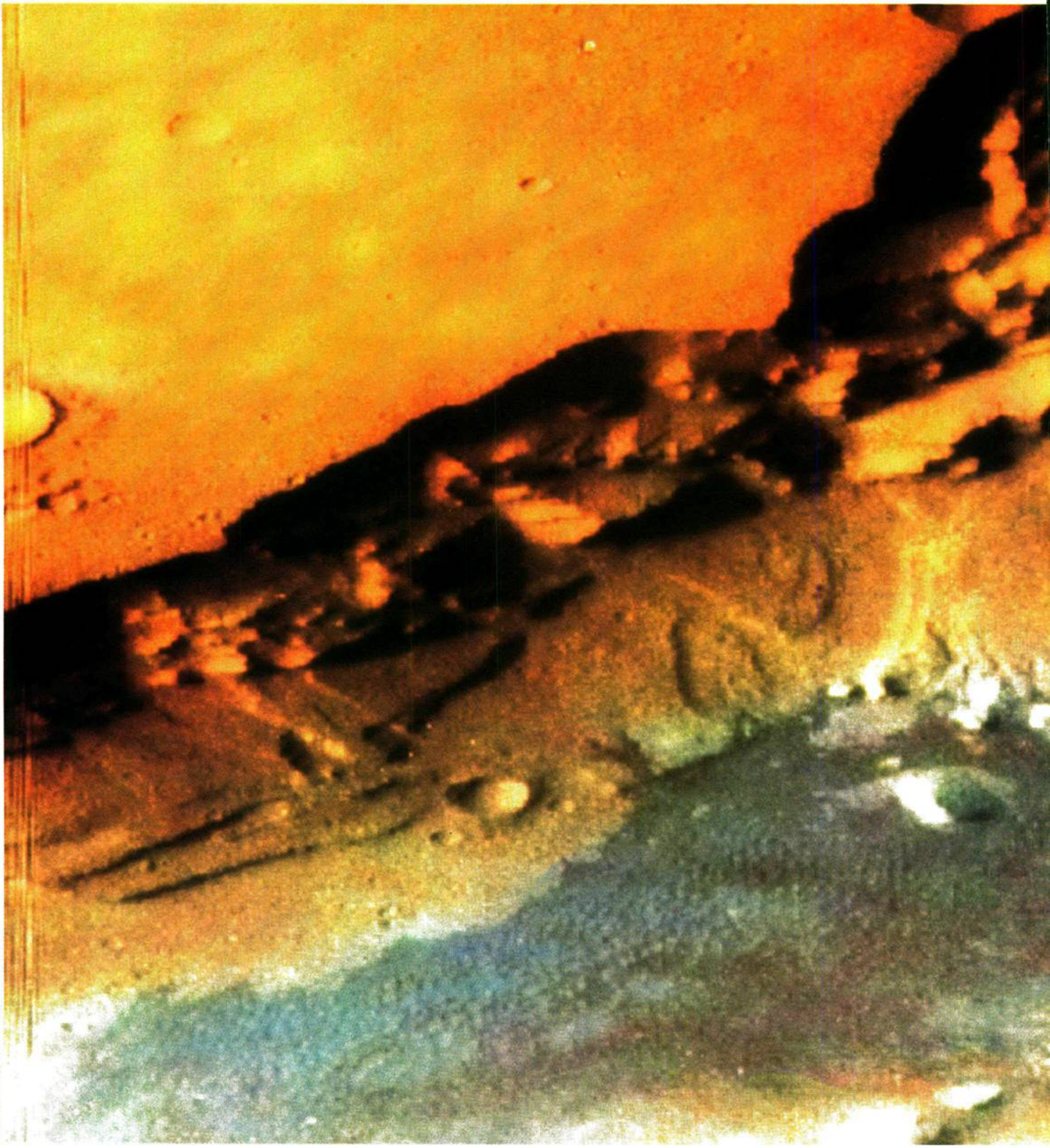
The Polar-Dune Mystery

Yet these sand fields are small compared to the greatest volume of Martian dune material, which lies near the north and south poles. Why the major Martian dune fields lie in the polar regions is a mystery. On Earth, most dunes occur in the tropics, within 30° of the equator, where strong sunlight and harsh conditions coincide to produce large expanses of bare ground.

The color and dark hue of the polar dunes suggest that they are not too different in composition from dunes in other regions like Syrtis Major. However, the north polar dunes (and possibly also those in the south) have no obvious volcanic source. The Tharsis and Elysium volcanic regions lie at the far southern edge of the great northern lowland plain. A variety of outflow channels — carved into thick layers of basaltic bedrock — empty onto these plains.

But the north polar dunes lie hundreds of miles away from these potential sand sources. Could vast quantities of sand somehow migrate across the rocky northern plains? Some scientists have proposed that the northern plains were once the site of an ocean. Could this play a role in transporting sand? No one yet knows the answers to these questions. One thing seems clear, however: Small amounts of dark dune material are eroding out of the polar layered deposits that formed over millions of years as dust and ice accumulated at the polar caps. This dark material — sand? dust? — could have been transported to the poles and gotten trapped in the ice and is now being re-exposed.

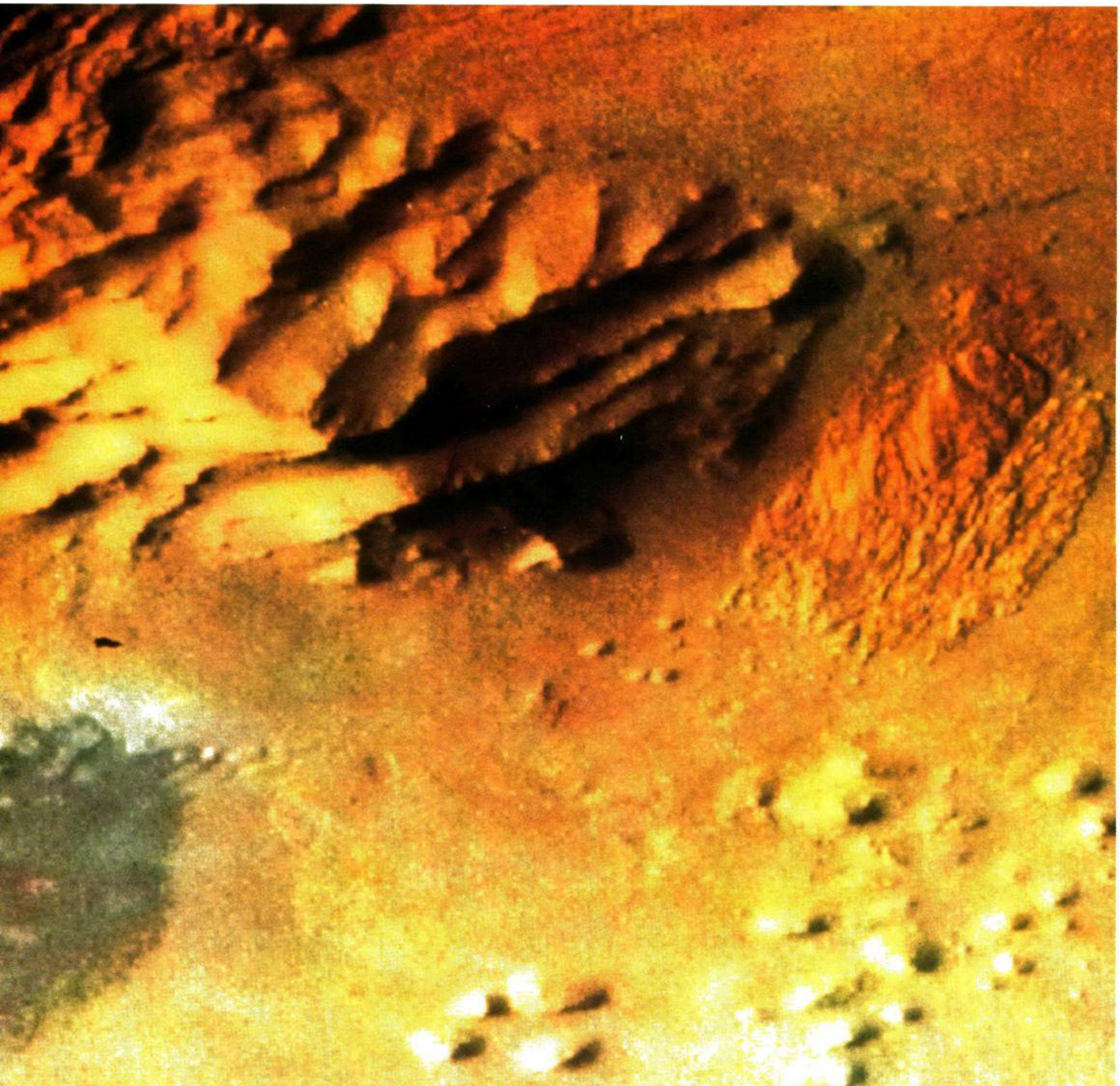
The mystery of the polar dunes raises two important



NASA/JPL; image processing by Paul Geissler

SCULPTED BY THE WIND, the dunes in Valles Marineris are made of sand eroded from massive beds of volcanic ash in the canyon walls.

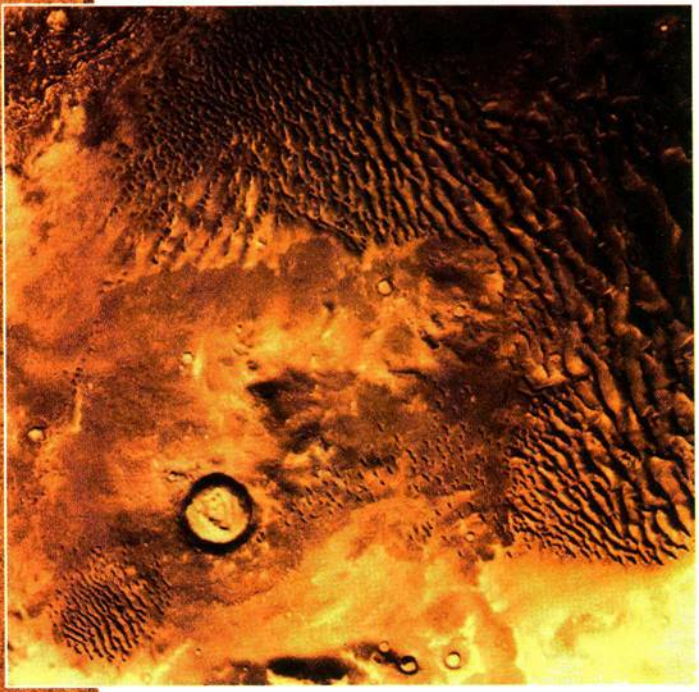
questions. How long can a sand grain last on Mars before it breaks down mechanically into dust? Second, how long do basalt minerals survive on the Martian surface before being chemically altered into clay and rust? For now scientists can't answer the chemical weathering question; the most they can say is that under present conditions chemical weathering must run very slowly. This leaves mechanical survival. Can sand grains hop and bounce across hundreds of miles before

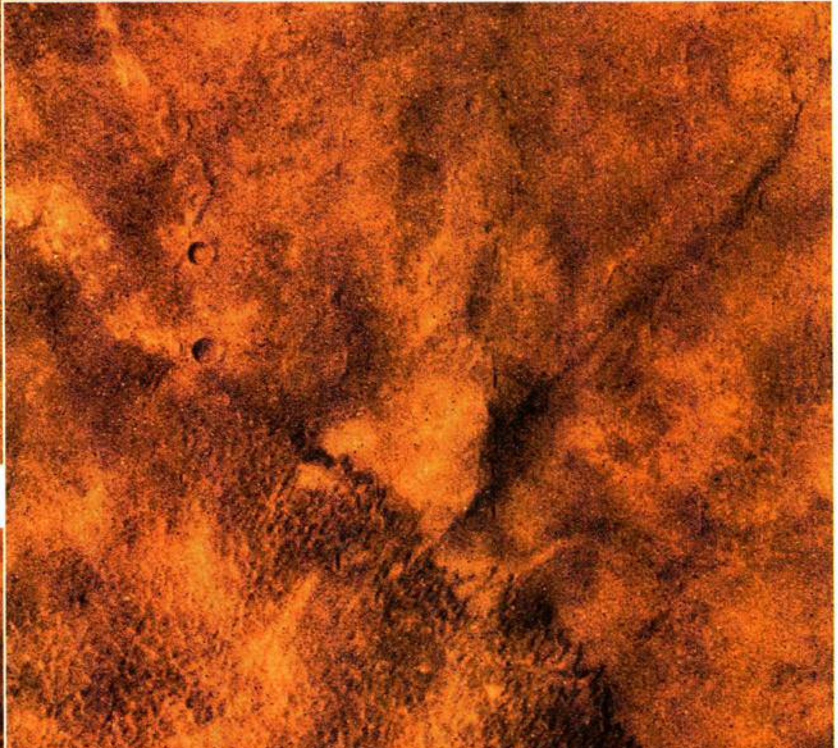


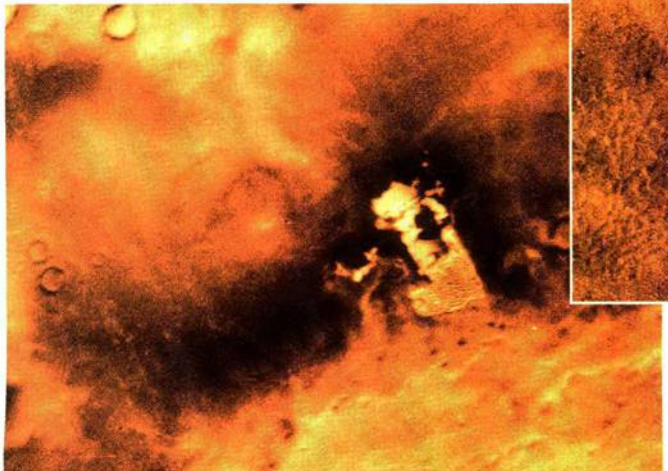
being trapped in the polar regions? Remember that it takes very high wind speeds to set grains into motion in the thin Martian air. Once grains get moving, they will hit the surface at speeds of 90 to 130 mph. At these speeds, sand grains can shatter on impact.

Common sense says that only the most durable minerals will survive such treatment. We have seen that because the polar dunes are dark like their equatorial counterparts, they are probably made of minerals common in basalts. No one knows for certain which basalt minerals are tough enough to travel hundreds of miles without being smashed to dust, but possibilities include iron-based minerals like ilmenite and magnetite. In any case, the polar dunes probably contain the most durable grains and thus may represent a more mature sand than that found closer to volcanic sources like Syrtis Major.

Scientists suspect the polar dunes of Mars probably







All photos NASA/JPL

SMALL AND BLACK, a dune field in Oxia (top left) stretches about 2 km. Inside Kaiser crater in Hellespontus, the dunes are 1 km high (top right); the crater shown is about 4 km across. Complex dunes (above) march along in Syrtis Major, while the tiny patch of dunes in Cimmeria (left) is bright with autumn frosts.

have a different history than the equatorial ones. But determining that history is a challenge. One of Mars Observer's most urgent tasks is to help determine the mineralogy and grain sizes of the polar dunes.

Resources in the Dunes?

Understanding dunes will be more than an academic exercise if mankind ever sends astronauts to explore Mars. While a future Martian colony would probably extract oxygen from ground water or ice, astronauts may find considerable value in the Martian sands and dunes. Although the question of economic resources on Mars pushes the available data beyond the limit, there are three potential uses for sand dunes on Mars: construction materials, metallic ores, and water.

The most obvious use for sand is to bury the living quarters of the colonists. Sand provides both thermal insulation and protection of habitats from incoming radiation. Sand might be used to produce concrete or ceramics to build with. Martian sands could also provide a source of metals. Recall that titanium- and iron-rich minerals, such as ilmenite and magnetite, are common in basaltic rocks. If Martian dune sands are basaltic, then iron and titanium should be present. Minerals like ilmenite and magnetite are denser than most non-metallic minerals, so they are harder to blow away than regular sand grains. Thus over time the wind will concentrate deposits of these minerals.

A third potential resource from Martian sand dunes is water. Many thick terrestrial sand dunes in cold climates contain layers or "lenses" of snow and ice. Dunes with ice exist in Antarctica, Iceland, Alaska, and even in temperate locations such as the Great Sand Dunes National Monument in Colorado. In winter, snow falls on the dunes. The blowing wind erodes both snow and sand from the windward slope and deposits them on the lee. Sometimes enough sand falls on the lee side to bury the snow, insulating it and preserving it well into summer. In a particularly cold year or in a colder climate, the ice layers may become permanent.

On Mars, we know many dunes populate the polar regions. During winter these dunes are covered by carbon dioxide frost, probably with some water ice or perhaps even snow. On any given day, heating from the Sun may penetrate no more than the uppermost 3 or 4 inches. In addition, temperatures at high latitudes — even in summer — do not often rise above the freezing point of water. It's conceivable that lenses of water ice could become trapped in the dunes, provided they are buried deeper than about a foot. Of course, whether the Martian dunes actually contain ice is presently unknown.

If dunes that might have ice in them are all located near the poles, why wouldn't Martian colonists simply use ice from the polar caps? The reason is that the polar caps themselves may not offer an ideal colony site due to their climate, harsh even by Martian standards. However, there is one mid-latitude site on Mars where seasonal frosts cover dunes. The sands in Proctor and other craters of Hellespontus (near 45° south) frost over in southern winter because the region lies at the northernmost extent of the south polar ice cap. The nearby Hellas Basin is already a candidate site for a colony because it lies as much as 3 miles below Martian "sea level," where increased atmospheric density will aid in landing spacecraft.

In the next few decades, scientists may have to decide where to put the first human outposts on the Martian surface. An important constraint in the decision will be the proximity to natural resources — and sand dunes will certainly be among the resources considered.

Martian dunes may offer astronauts shelter and resources — and possibly water.

Mysteries Await Mars Observer

Later this year, Mars Observer will begin systematically mapping the planet with a variety of instruments. Its super-high-resolution camera will resolve objects as small as 10 feet across in areas 2 miles wide, allowing detailed study of dune shapes. Its laser altimeter is ideal for measuring the height, spacing, and profile of Martian dunes — information vital for assessing the volume of sand present.

Surface composition is also critical. The gamma-ray spectrometer will measure the elemental chemistry of the surface with a resolution good enough to identify the composition of dark areas like Syrtis Major. In addition, it can detect water ice buried to depths of about 3 feet. Unfortunately, the resolution isn't good enough to locate the (probably small) water-ice lenses that may be buried in the dunes in places like Hellespontus.

More information about surface composition will come from the spacecraft's thermal emission spectrometer. It uses the fact that most minerals have different spectral patterns in middle-infrared wavelengths. With a resolution of 2 miles, it can easily determine the composition and particle sizes of most dune fields. With these data, scientists will be able to study Martian weathering rates and begin to pinpoint the sources of Martian sand. Even more exciting, Mars Observer will pass over each pole 12 times a day. This will give scientists a wealth of data to determine the composition of the polar dune fields and to resolve the mysteries of how sand moves in these enigmatic regions.

The challenge for scientists working with Mars Observer — and for future Mars exploration — will be to use every clue available, including the nature of the wind-blown sands, to tell us what the planet Mars is all about. ☐

Ken Edgett is a geology student at Arizona State University, Paul Geissler is a research scientist at the University of Arizona's Lunar and Planetary Laboratory, and Ken Herkenhoff is a planetary scientist at the Jet Propulsion Laboratory.

A Peculiar Twist

Unseen matter in the outer regions of NGC 4753 twists the disk of this lens-shaped galaxy.

by Thomas Steiman-Cameron

Ninety percent or more of the matter in the universe is invisible, so astronomers have a difficult time trying to map its location. Theorists have tried to model the distribution of this dark matter, but their models are inconclusive. Some suggest the mass is spread more or less spherically around galaxies, while others indicate the matter is flattened. But observers have had a hard time testing these ideas because of its invisibility. So they have had to look for indirect indicators of its distribution.

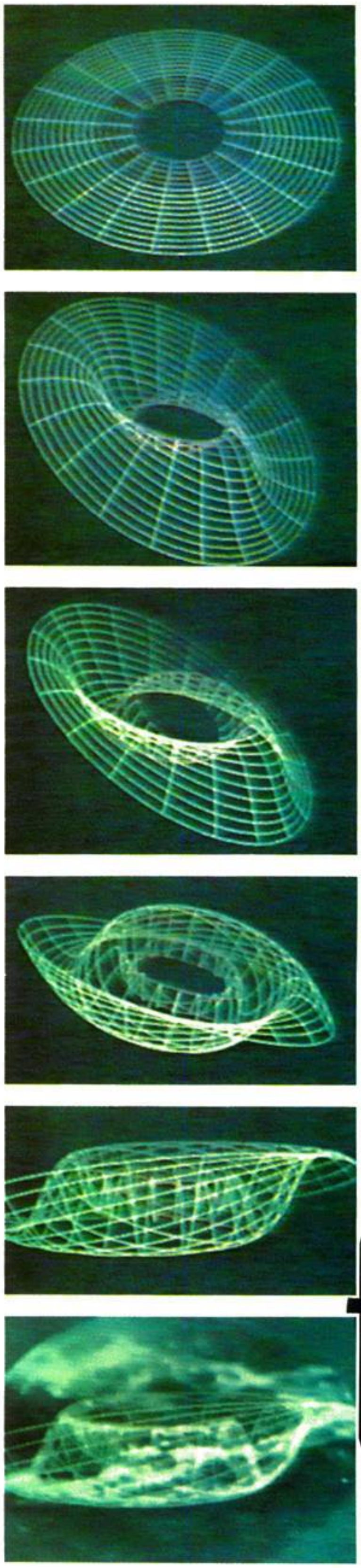
Recent computer simulations indicate that the dusty disk found in some galaxies may make this task easier. Although many galaxies have disks, most fall along the plane of the galaxy. What astronomers need in order to investigate dark matter are disks that are cocked slightly to the rest of the galaxy. These off-kilter disks permit them to study the gravitational pull of the dark matter on the disk. The lens-shaped galaxy NGC 4753 provides an ideal opportunity. Lens-shaped or lenticular galaxies typically have disks that are free of dust and lie in the plane of the galaxy, but NGC 4753 (number 4753 in the *New General Catalogue*) is a noticeable exception.

NGC 4753 appears at magnitude 9.9 in the constellation Virgo, and lies about 28 million light-years from Earth. It has captured material, presumably from another galaxy, and it's this gas and dust that now form a disk in NGC 4753. The matter probably wasn't captured recently because the galaxy had to have rotated six or more times to smear the material out into the disk we see. Given the disk's rotation speed of 300 kilometers per second, this means that the collision took place 500 million or more years ago.

By chance the dusty disk inclines slightly (by 15 degrees) to NGC 4753's plane. If the disk weren't inclined, it would remain flat because the matter in the galaxy's outer regions would pull on the disk evenly. But the gravitational pull of these regions on an inclined disk causes the disk's rotation to change direction, or precess. Because the disk's outer regions rotate more slowly than the inner regions, the precession twists the disk. Computer models of the twisting can reveal how much dark matter exists in the galaxy and where it is located.

Richard Durisen of Indiana University, John Kormendy of the Institute for Astronomy in Hawaii, and I have constructed a computer model of NGC 4753's twisted disk. The model indicates that the unseen matter is nearly spherical but flattened slightly, somewhat like a fat hamburger bun, and less flattened than the galaxy's luminous matter. Also, most of the galaxy's mass must be dark matter to account for the severe twisting.

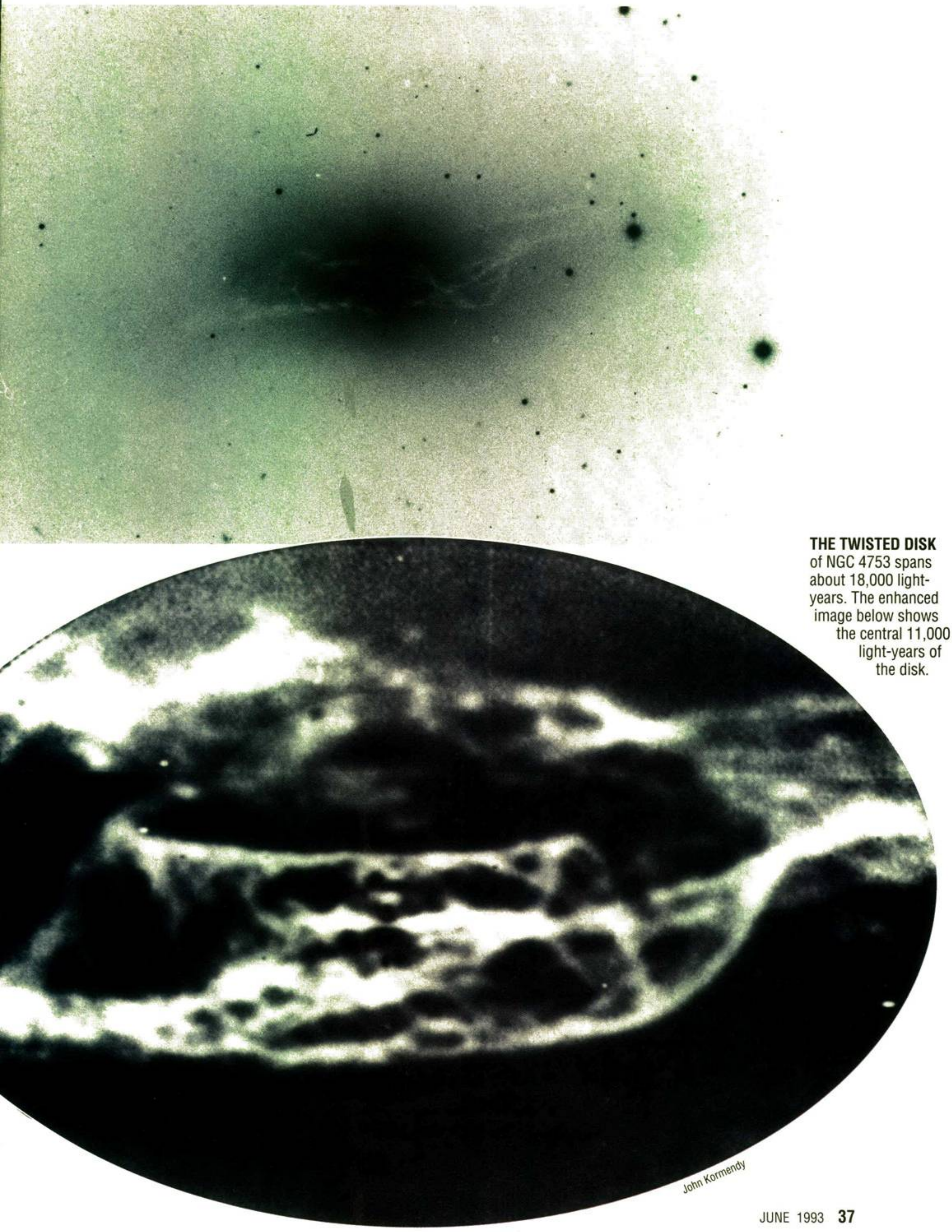
The most obvious characteristic of a galaxy is its shape. It reflects how the galaxy formed and has since evolved. Yet the invisibility of most galactic matter has prevented astronomers from learning the true shapes of galaxies. But now they can probe the distribution of galactic matter — seen and unseen — by studying twisted disks. □



Thomas Steiman-Cameron

DARK MATTER TWISTS THE DISK in this series of frames from a computer simulation, resulting in a shape incredibly similar to that of NGC 4753.

Thomas Steiman-Cameron, an astronomer at Lick Observatory and NASA's Ames Research Center, studies the shapes of galaxies.



THE TWISTED DISK of NGC 4753 spans about 18,000 light-years. The enhanced image below shows the central 11,000 light-years of the disk.

John Kormendy

COSMOLOGY

THE AGE PARADOX

Controversy surrounds a basic fact about the universe — its age. Stellar astronomers claim the most ancient stars appear to be several billion years older than the universe itself.

by Ray Jayawardhana

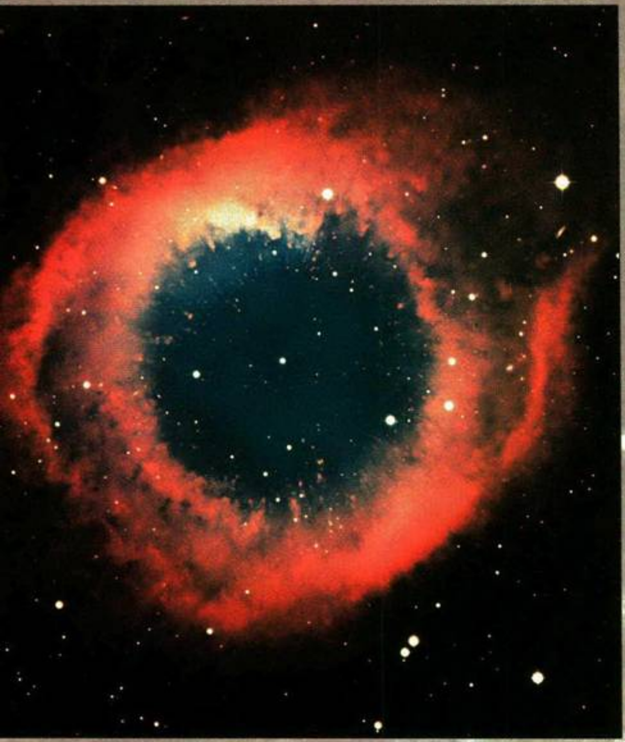
Cosmologists say the universe may be 8 to 15 billion years old. Stellar astronomers disagree. They say the oldest stars are much older, perhaps 16 to 19 billion years old. Because the oldest stars can't be older than the universe in which they lie, this age paradox presents a thorny problem for astronomers.

Resolving the age paradox is vital to understanding how the universe formed and evolved, but astronomers are having difficulty pinning it down.

Either the galactic distance scales used to find the age of the universe or the stellar evolution models used to find stellar ages must be wrong. Or perhaps both sets of data have flaws, as recent evidence suggests. Uncovering the flaws will provide astronomers with new information about how stars age, the distances to galaxies, and the expansion of the universe. Of the two ages, the age found from galactic motions, the cosmological age, is harder to determine.

GALAXIES PRESENT BOTH SIDES OF THE AGE PARADOX. The blue side of this galaxy reflects the young 8-billion-year age of the universe found by cosmologists from the motions of galaxies. The yellow side represents the 16- to 19-million-year age of the universe found by stellar astronomers for the most ancient stars in galaxies. Galaxies can't be young and old at the same time, so which age is correct?

ASTRONOMY: Thomas L. Hunt



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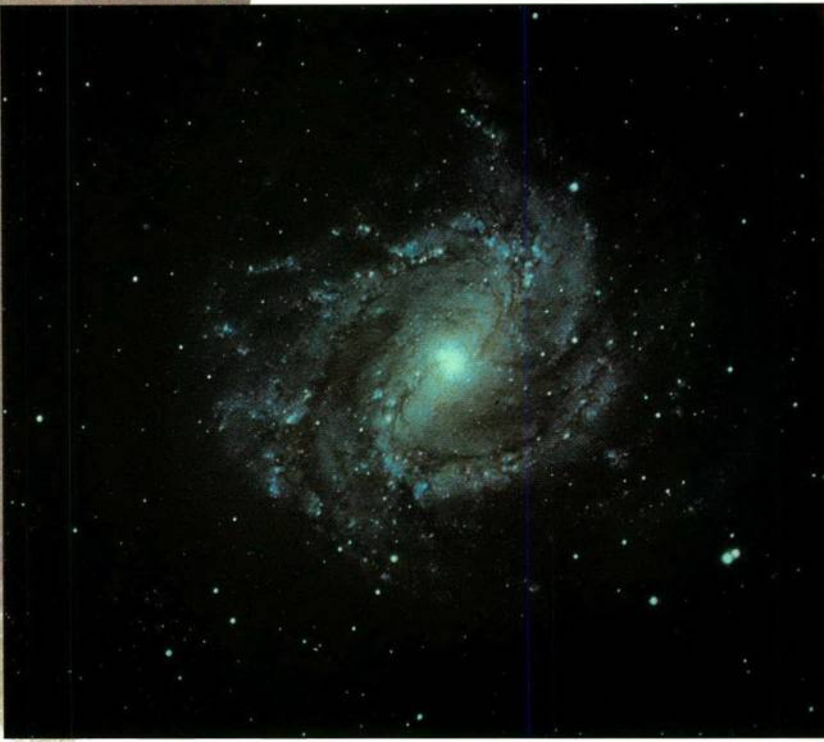

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NEW STEPS IN THE DISTANCE SCALE come from bright, large planetary nebulae (similar to the Helix Nebula above) in distant galaxies, such as M83 (right). They confirm the distances found from other techniques.

Finding the Cosmological Age

Present measurements of the age of the universe had their beginnings in the 1920s when Edwin Hubble discovered that the universe is expanding. He observed that galaxies move away from each other and that more distant galaxies travel faster. But galaxies don't actually move through space. They are being pulled along with space as space expands. This expansion was caused by the big bang, the massive explosion that formed the universe.

Cosmologists determine the age of the universe by measuring apparent galactic motions. This method is akin to finding the time it takes to drive from one city to another by dividing the distance by the car's speed. Likewise astronomers find a galaxy's travel time since the big bang, which is equal to the age of the universe, by dividing how far the galaxy has traveled by its speed.

Errors in a galaxy's speed or distance lead to a wrong value for the age, so astronomers use instead the average expansion rate found from many galaxies. They find the expansion rate, called the Hubble constant (H_0, pronounced "H-naught"), by dividing the speeds of galaxies by their distances. The units of H_0 are unusual: kilometers per second per million light-years. For example if H_0 equals 30 kilometers per second per million light-years, a galaxy 100 million light-years away will recede from us at 3,000 km/s, 10 times faster than a galaxy 10 million light-years away traveling at 300 km/s.

One divided by the Hubble constant ($1/H_0$) gives an estimate of the age of the universe that astronomers call the Hubble age. This is the age that the universe would have if it contained no matter.

But stars and galaxies fill our universe. So its age must be less than the Hubble age because the gravitational pulls of the stars and galaxies slow the expansion over time. The slowing expansion means that galaxies traveled faster in the past than they do today. The faster-moving galaxies of eons ago could travel the same distance in less time than the slower-moving galaxies of today. Thus the Hubble age, which uses today's expansion rate in its calculation (the "naught" in H_0 signifies the present value of Hubble's constant), leads to an upper limit to the age. The actual age is less, probably around two-thirds of the Hubble age.

How can the oldest stars in our Galaxy be older than the universe?

Climbing the Distance Ladder

The Hubble age, and other estimates that derive from it, are only as accurate as the galactic speeds and distances that astronomers use to measure it. Finding a galaxy's speed is a fairly easy task. Astronomers use the Doppler shift: movement of an object away from us shifts the dark lines in its spectrum to the red, while motion toward us shifts the lines to the blue. The amount of shift in a galaxy's spectrum is proportional to its speed. Almost all galaxies show an apparent redshift because the universe is expanding.

On the other hand, measuring a galaxy's distance is a tricky business. Finding the distance to a galaxy involves using a series of steps that astronomers call the cosmic distance ladder, or scale. The first rung of the

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THE VIRGO CLUSTER PROVIDES a test of the methods used to measure galactic distances. Virtually all methods now yield the same distance to the cluster of galaxies and give an age of 8 to 12 billion years for the universe.

ladder starts with the Earth-to-Sun distance and builds outward to the distances of other planets and nearby stars. The highest rungs rise out to the farthest galaxies and quasars.

Intermediate steps use "standard candles," objects having the same luminosity, to measure distances to distant stars and nearby galaxies. Knowing how bright the standard candle really is and comparing that with how bright the standard candle appears in a galaxy enables researchers to determine how far away it is. Previous steps in the distance scale help establish the distances found with subsequent ones, so astronomers leapfrog their way out to ever more distant galaxies.

Cepheids, a special breed of supergiant stars, are one of the standard candles used along the bottom rungs of the distance ladder. These stars vary regularly in brightness as they expand and contract in size. The speed at which they change brightness relates directly to their luminosity. So astronomers can deduce a Cepheid's luminosity by measuring how quickly it changes, and then find its distance by comparing its luminosity to how bright it appears. Because these stars never get extremely bright, they are useful for finding distances to relatively nearby galaxies, out to about 25 million light-years.

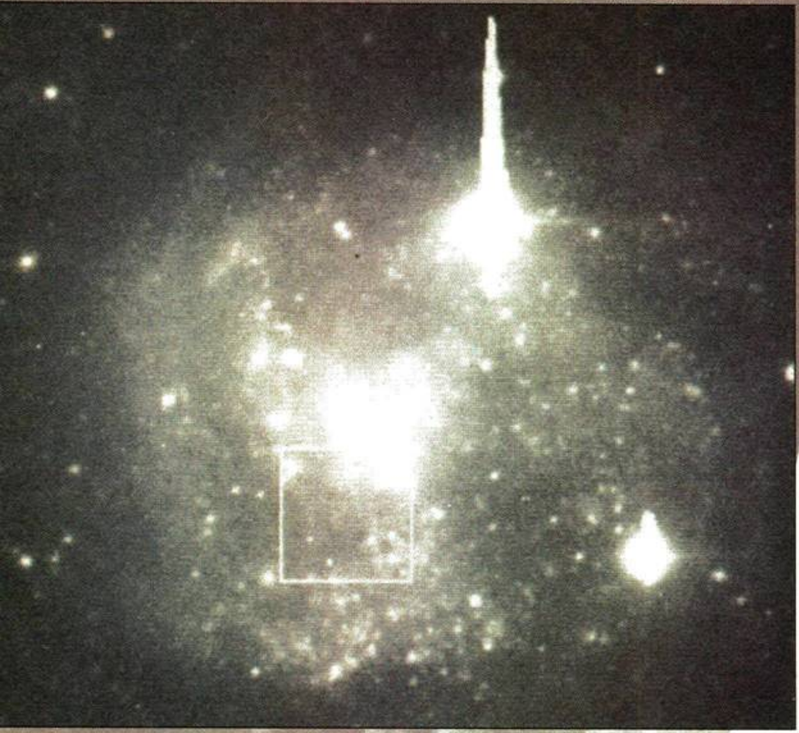
For more distant galaxies, researchers must use a brighter standard candle. Type Ia supernovae qualify as good standards because they all attain the same peak luminosity, which is several magnitudes brighter than Cepheids. When these stars collect enough material from a companion star, they explode violently and brighten rapidly, rivaling the brightness of the galaxies in which they lie. They can be seen out to distances of a billion light-years or more.

Unfortunately, stepping between the rungs represented by Cepheids and type Ia supernovae isn't easy— there's a hole in the ladder. Astronomers see Cepheids only in relatively nearby galaxies. But type Ia supernovae occur rarely, so observers hardly ever see these stellar outbursts in nearby galaxies. Instead they must look for supernovae among the larger number of distant galaxies, creating a gap between the Cepheid and supernova distance scales. A further problem with supernovae is that the peak luminosity they reach is uncertain, making their distances imprecise.

The hole in the ladder has forced astronomers to use other methods to bridge the gap. The so-called Tully-Fisher method uses the fact that more massive galaxies are generally more luminous and rotate faster than less massive galaxies. Radio astronomers measure a galaxy's rotation rate from the width of the 21-centimeter spectral line emitted by the galaxy's hydrogen gas. The wider the line, the faster the galaxy is rotating and the more massive and luminous it is. Comparing this estimated luminosity with the observed brightness gives astronomers a measure of the galaxy's distance. The Tully-Fisher method yields values for the Hubble constant between 15 and 30 kilometers per second per million light-years, corresponding to ages from 14 to 7 billion years. But these results are too imprecise. Astronomers need more precise measurements of the Hubble constant in order to determine accurately the distances of faraway galaxies and the age of the universe.

Building New Rungs

Within the last five years, astronomers have used a new standard candle with great accuracy. They use planetary nebulae, large shells of glowing gas found around old stars. These dying stars kick off shells of gas because they are not massive enough to explode as supernovae. A team led by George Jacoby of Kitt Peak National Observatory found that the brightest planetary nebulae in galaxies make ideal standard candles



both photos courtesy Abhijit Saha/STScI, and NASA

THE UNIVERSE MAY BE 15 BILLION YEARS OLD, as suggested by observations of Cepheid variable stars in the galaxy IC 4182. Enlarging the bottom of the box in the image above shows one of the Cepheids studied (arrow, above right).

because they all have nearly the same luminosity and are bright enough to be seen at great distances. These objects are especially useful because they usually lie far from the crowded central regions of galaxies and therefore can be observed easily. Also a unique signature in their spectrum helps to identify them.

Jacoby's team has established the distance to the nearby Virgo cluster of galaxies using planetary nebulae and found that their results agree well with those obtained from other methods. Following this confirmation, several research groups rushed to use the new cosmic yardstick. They found an age of 8 to 12 billion years for the universe.

Cosmologists strive to develop new rungs in the distance scale and to determine the Hubble constant more precisely. But despite their efforts to resolve the age paradox, cosmological ages hover around 10 billion years. The universe still appears much younger than the 16- to 19-billion-year age of the oldest stars.

Dating Ancient Stars

Stellar astronomers tell us that the oldest stars visible today lie in globular clusters and are around 16 to 19 billion years old. Globular clusters are giant collections of up to a million stars that orbit the center of our Milky Way Galaxy but reside outside the Galaxy's disk. All the stars in a globular cluster formed at the same time, so they have the same age. But massive stars in the cluster burn up their nuclear fuel faster than smaller stars, and thus become giant stars sooner. Astronomers observe which cluster stars are now evolving into giants and then use theoretical estimates of how long it takes for these stars to become giants to find the cluster's age.

Looking at just one star in a cluster can give an erroneous age for the cluster. So astronomers plot the temperatures and luminosities of many stars and compare them with theoretical estimates of what the temperatures and luminosities should look like for different ages.

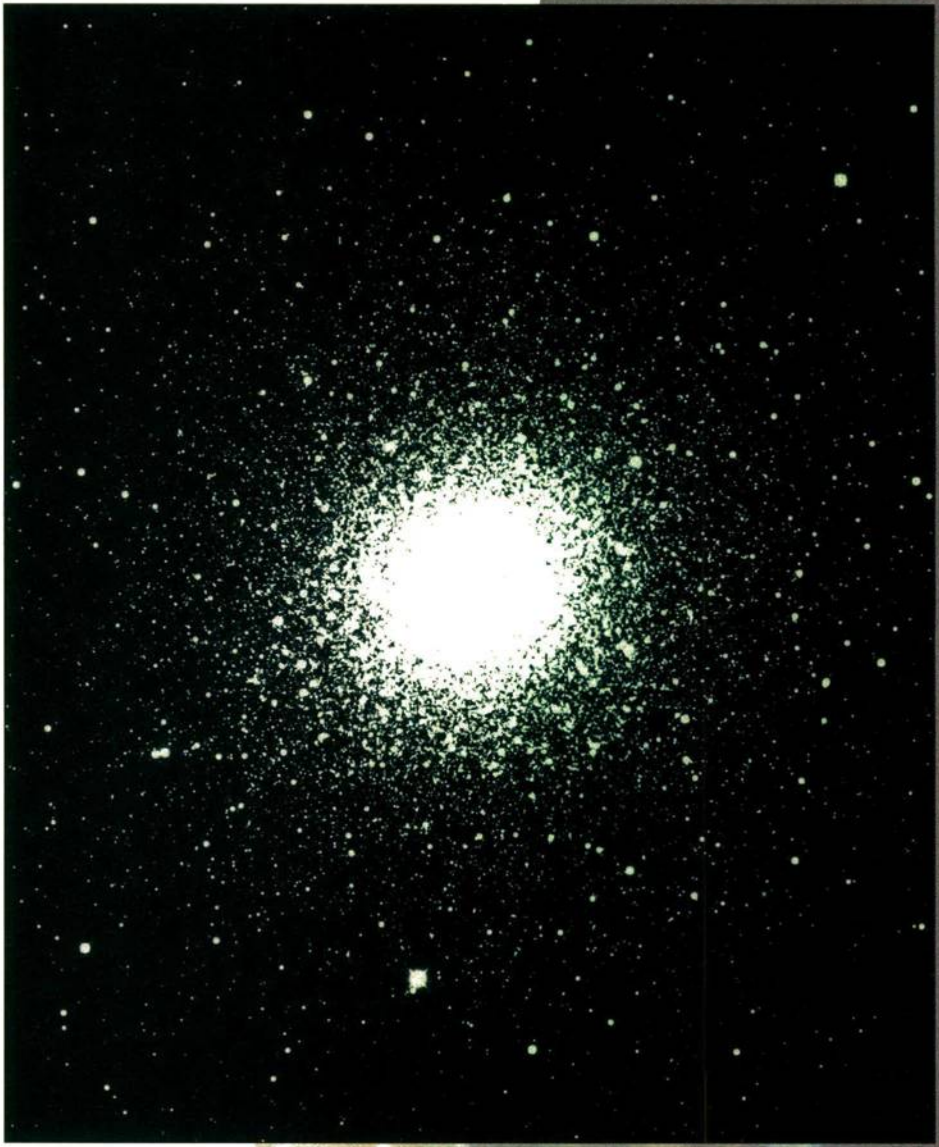
Don VandenBerg of the University of Victoria, Peter Stetson of the Dominion Astrophysical Observatory, and Michael Bolte of Lick Observatory have studied several globular clusters. They have estimated an age of 15 to 17 billion years for stars in the globular cluster M92, in Hercules. In fact M92 may be even older. An Italian group led by Oscar Straniero and Alessandro Chieffi of the Institute for Astrophysics in Frascati thinks it may be around 19 billion years old.

Astronomers argue both ages can't be right. But which one is wrong?

These ages conflict drastically with estimates of the cosmological age of the universe. But stellar evolution theories may contain flaws, causing astronomers to believe globular-cluster stars are older than they really are. Yale University researchers including Pierre Demarque, Marc Pinsonneault, and Brian Chaboyer recently have studied a stellar process that previous models did not include. Diffusion within stars causes heavier elements such as lithium to settle closer to the star's center than the lighter ones such as hydrogen. This process changes how the star transports energy from its center to its surface and thus changes the temperature and luminosity of the star. So diffusion has a noticeable effect on the aging of stars and causes astronomers to misgauge the age of a cluster from stellar temperatures and luminosities.

Including the effects of diffusion in new evolutionary models, Demarque's group found that the oldest globular cluster stars are at least 16 billion years old. Unfortunately this leaves the age paradox intact. And a discovery made by another Yale astronomer makes things worse. Young-Wook Lee looked in the central bulge of our Galaxy at the oldest RR Lyrae stars, variable stars similar to Cepheids. He found that these stars are about 1.3 billion years older than the oldest globular cluster stars. His discovery pushes the age of the oldest stars to at least 17 billion years.

Although errors exist in the stellar ages, increases in age so far seem to offset any decreases in age. While further decreases may be possible as theorists make advances in understanding stellar evolution, the oldest stars appear no younger than 16 billion years. At present it seems that improved studies won't result in stellar and cosmological ages' meeting halfway. But some recent results from the Hubble camp point to a possible resolution of the age paradox from the cosmological side.



National Optical Astronomy Observatories

THE OLDEST STARS APPEAR OLDER than the universe. Estimates of the age of the globular cluster M92 make it 16 to 19 billion years old. And some stars near the center of our Galaxy may be even older.

Resolving the Paradox

In June 1992 a team of astronomers from the Space Telescope Science Institute and the Carnegie Observatories announced a result that may fill the hole in the distance ladder. The team, which included Allan Sandage, used the Hubble Space Telescope to observe 27 Cepheids in a faint galaxy in Canes Venatici known as IC 4182. They picked this galaxy because astronomers had observed a type Ia supernova in this galaxy in 1937.

The earlier study resulted in an inaccurate distance to this galaxy because the supernova's peak luminosity was uncertain. But Sandage's team used the yardstick provided by the new Cepheid observations to calibrate the peak luminosity of the supernova and to determine a precise distance to the galaxy. Using this new distance, the team found for the Hubble constant a value of 14 kilometers per second per million light-years. This corresponds to an age of 15 billion years and comes close to resolving the age paradox.

While Sandage says that he is confident of the result, many others counsel caution. Michael Pierce of Kitt Peak National Observatory points out that IC 4182 contains a lot of dust, which could make the Cepheids look fainter and thus confound distance estimates. If Pierce is right, the Hubble constant derived for this galaxy would be larger and the age of the universe smaller than determined by Sandage.

And what of the Hubble constant values found for the Virgo cluster? The conflict between these values and that of Sandage's team means that the search for a cosmological age is far from over. Resolving the cosmological age problem may come from observing more galaxies. According to Jeremiah Ostriker of Princeton University, galactic motions independent of the expansion of the universe could confuse H_0 measurements. The way to avoid this problem, he says, is to use a large number of galaxies to calculate H_0.

Even if astronomers can agree on a cosmological age, the age paradox may remain — for a while. But most astronomers believe that as they use more reliable distance indicators and further improve stellar evolution theory, the cosmological and stellar ages will come into agreement. After all, we all know stars can't really be older than the universe itself. □

Ray Jayawardhana, an astronomy student at Yale University, has written for Science.

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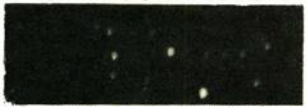

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25mm Cross-hair 1¼" eyepiece (12X)	**$39**
Large mounting rings for 80mm Finder	**$55**
1¼" Star Diagonal **$39**, Mounting Brackets,	**$39.50**
1¼" 45° diagonal for correct left-right views	**$52.44**

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2" adapter for C-8, Meade 2080, etc.	**$26.00**
2" adapter for C-80, C-100 refractor	**$39.50**
2" adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2" adapter for C-6, Comet Catcher, Meade 312	**$30.00**

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1" long 1¼" OD thread-in extension	**12.00**
2½" long extension (holds 1¼" filters)	**16.00**
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3" long extension for 2" eyepieces*	**$26.00**
2" long extension for 2" eyepieces*	**$26.00**

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2"/1¼" reducing bushing,threaded 48mm*	**$20.00**
2"/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼" adapter	**$25.00**
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2" Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

Galaxy NGC 4631 and companion NGC 4627 in Canes Venatici. 60 minute photo by Eraldo Guidolin (in Padova, Italy) using an 8" f/10 telescope, a LUMICON Cassegrain Easy-Guider at f/6 and hypered 2415 film. Mr. Guidolin stated, "With your Cassegrain Easy-Guider I have taken hundreds of perfectly guided high quality photographs."

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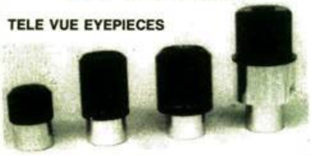
TELE VUE EYEPIECES



Genesis 4" f/5 4 element fluorite	**$1595**
Pronto 70mm f/6.4 apochromat w/2" diagonal	**$749**
Pronto 70mm f/6.4 w/Porro prism	**$689**
Complete Equatorial Mount	**$795**
Motor Drive for above mount	**$239**
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	**$89**
1.8x or 2.5x Tele Vue Barlow Lens	**$89**
2" Giant Barlow - 2x	**$189**
32mm Plossl, widest true field in 1¼"	**$109**
55mm 2" Plossl, widest possible field	**$219**
15mm Wide-Field, 1¼" eyepiece, 65°	**$135**
19mm Wide-Field, 1¼" eyepiece, 65°	**$145**
24mm Wide-Field, "Rich-Field!" 65°	**$169**
32mm Wide-Field, 2" eyepiece, 65°	**$239**
40mm Wide-Field, "Rich-Field!" 65°	**$299**
4.8mm Nagler, 82° field, 1¼" eyepiece	**$149**
7mm Nagler, 1¼" eyepiece, 82° field	**$189**
9mm Nagler, 82° field, 1¼" or 2"	**$219**
13mm Nagler, 82° field, 1¼" or 2"	**$249**
12mm Nagler, Type II, 82°, 1¼"/2"	**$249**
16mm Nagler, Type II, 82°, 1¼"/2"	**$289**
20mm Nagler, Type II, 82°, 2" only	**$340**
1¼" Paracorr Visual Coma Corrector	**$159**
2" Paracorr Visual Coma Corrector	**$249**
NEW! 22mm Panoptic 1¼"/2", 68°	**$249**
NEW! 35mm Panoptic 2", 68° field	**$325**

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	**H-Alpha**	**(MV)**
46, 48, 49mm	**$49.00**	**$39.00**
52, 55, 58, 62mm	**$59.00**	**$49.00**
67, 72, 77mm	**$69.00**	**$59.00**
82mm	**$79.00**	**N/A**

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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All foreign orders add 8% ($10 minimum)
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Prices subject to change w/o notice.
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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$39.50** 1.52" **$45.00** 1.83" **$49.50**
2.14" **$59.50** 2.60" **$75.00** 3.10" **$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

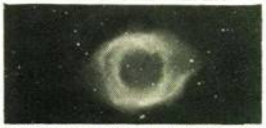
90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

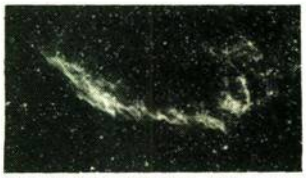


Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter.** He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!
"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!
*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*
Astronomy, Feb. 1991

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	**$59.50**
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	**$79.50**
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	**$119.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$119.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	**$299.50**
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$119.50** UHC, O-III, H-Beta,	**$199.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$199.50**
Set of both premium **DEEP-SKY** and **UHC Filters** (Save 11%) ... 1¼" **$159.50**; 48mm	**$279.50**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	**$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... **1¼" $99.50, 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	**$20.00**

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

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LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

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All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece system	**$99.50**

Guider for Hasselblad **$350,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad **$198,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

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48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$229,** Mamiya 645**$129**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**

3. **LUMICON Digital Drive Corrector . $249**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

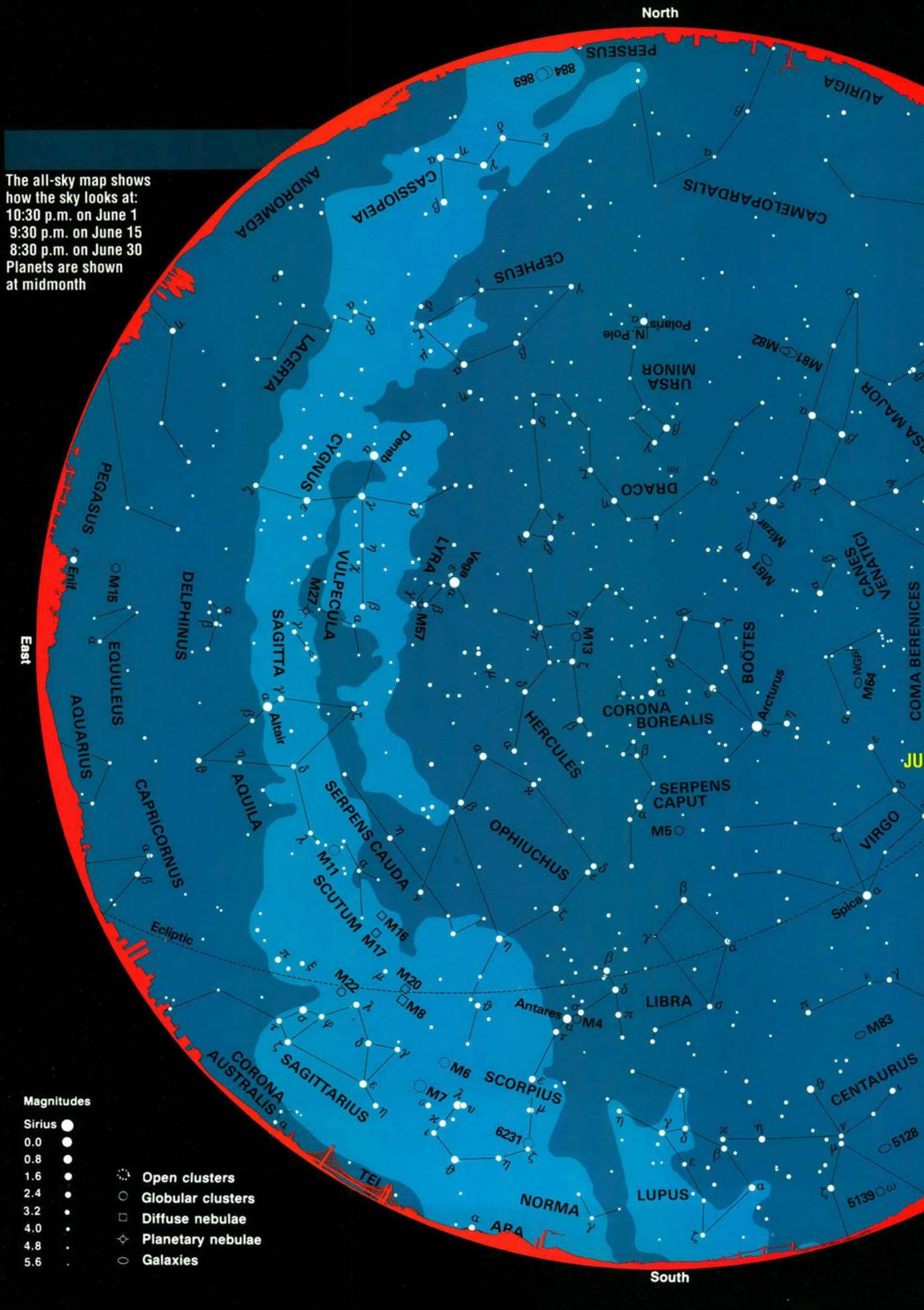
Declination motor (state telescope) ... **$109**
Variable dec. speed drive w/built-in 5AH battery **$299**

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).***No C.O.D.s.***

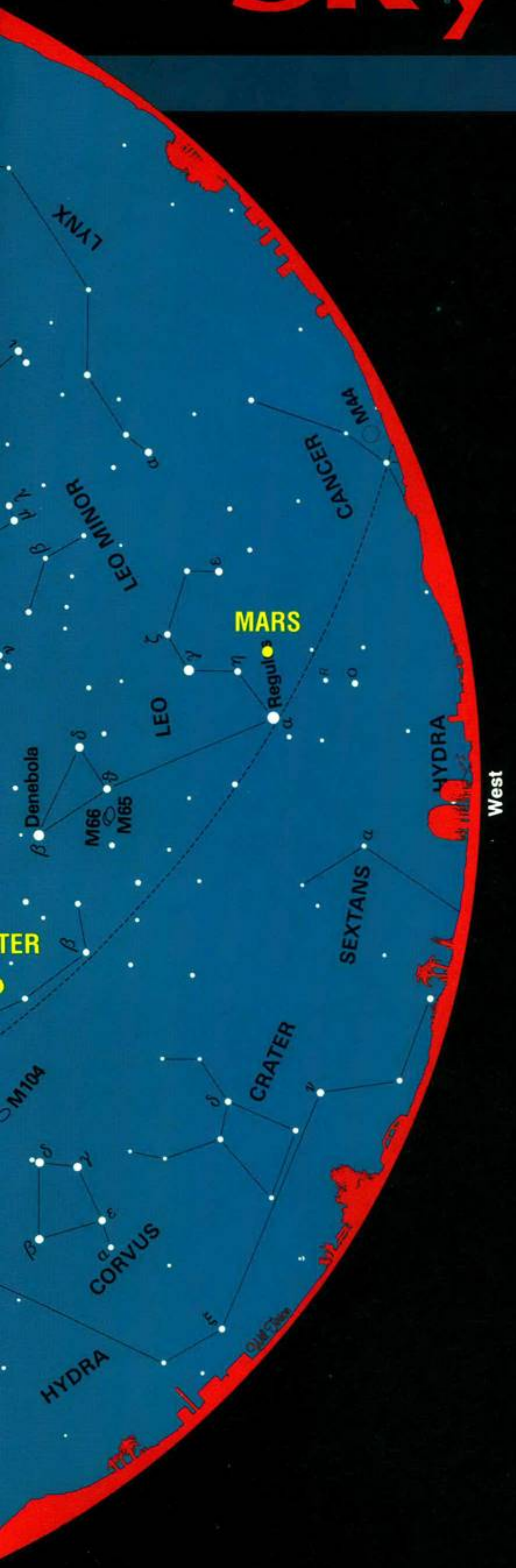
Film Type, 35mm	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

The all-sky map shows how the sky looks at:
10:30 p.m. on June 1
9:30 p.m. on June 15
8:30 p.m. on June 30
Planets are shown at midmonth


North
PERSEUS
884
869
AURIGA
CASSIOPEIA
ANDROMEDA
CAMELOPARDALIS
CEPHEUS
Polaris
N. Pole
URSA MINOR
M81
M82
URSA MAJOR
LACERTA
Deneb
CYGNUS
DRACO
Mizar
M51
CANES VENATICI
PEGASUS
Enif
M15
DELPHINUS
VULPECULA
M27
LYRA
Vega
M57
M13
BOÖTES
COMA BERENICES
M64
NGP
East
EQUULEUS
SAGITTA
Altair
HERCULES
CORONA BOREALIS
Arcturus
AQUARIUS
CAPRICORNUS
AQUILA
SERPENS CAUDA
SERPENS CAPUT
M5
JU
OPHIUCHUS
VIRGO
M11
SCUTUM
M16
M17
Spica
Ecliptic
M22
M20
M8
Antares
M4
LIBRA
M83
CORONA AUSTRALIS
SAGITTARIUS
M6
M7
SCORPIUS
CENTAURUS
6231
5128
5139
TEL
NORMA
LUPUS
ARA
South
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

June 1993



Map Art by Wil Tirion

LUNAR ECLIPSE ON JUNE 4

The longest total lunar eclipse since 1982 graces the sky over much of the globe on June 4. Viewers in western North America can catch the initial partial stages, while those on the west coast see the start of totality. People in Hawaii, Australia, New Zealand, Japan, and eastern Asia can enjoy the entire eclipse, and those in central Asia will witness the last partial phases.

MERCURY AT ITS BEST

Look low in the west-northwest 30 to 45 minutes after sunset and you should see a bright point of light shining through the twilight glow. This is Mercury, a normally elusive planet that's easy to spot now as it puts on its best show of 1993 in June's evening sky.

VENUS BRIGHTENS THE DAWN

Venus dominates the eastern predawn sky all month, climbing higher each day even after it reaches greatest elongation on June 10. This is the best month to monitor Venus' appearance in a telescope, as the planet's phase waxes from crescent to gibbous.

MARS JOINS REGULUS

The Red Planet moves slowly through the background stars of Leo this month. On the night of June 21/22, that motion carries Mars within a degree of Leo's brightest star, 1st-magnitude Regulus. The planet and star appear nearly the same brightness, which accentuates the color difference between ruddy Mars and white Regulus.

Calendar of Events

1 Jupiter is stationary
4 Full Moon is at 9:02 a.m. EDT; total lunar eclipse
7 Asteroid Harmonia is at opposition
10 Venus is at greatest western elongation (46°)
The Moon passes 7° north of Saturn, 1 p.m. EDT
Saturn is stationary
12 Last Quarter Moon is at 1:36 a.m. EDT
The Moon is at apogee (251,184 miles from Earth), 12:20 p.m. EDT
14 Jupiter is at aphelion (507.0 million miles from the Sun)
16 The Moon passes 6° north of Venus, 6 a.m. EDT
17 Mercury is at greatest eastern elongation (25°)
19 New Moon is at 9:52 p.m. EDT
21 Mercury passes 7° south of Pollux, 4 a.m. EDT
Summer solstice is at 5:00 a.m. EDT
The Moon passes 4° south of Mercury, 9 p.m. EDT
22 Mars passes 0.8° north of Regulus, 6 a.m. EDT
24 The Moon passes 7° south of Mars, 1 p.m. EDT
25 The Moon is at perigee (229,508 miles from Earth), 1:27 p.m. EDT
26 First Quarter Moon is at 6:43 p.m. EDT
The Moon passes 7° south of Jupiter, midnight EDT

Eye on the Sky

by Deborah Byrd

TOTALITY COMES TO THE MOON

The Moon plunges through the heart of Earth's shadow on June 4, creating the longest total lunar eclipse in over a decade. Totality lasts 97 minutes, a fraction of a minute longer than the August 17, 1989 eclipse and about 10 minutes shorter than the last longer eclipse, which occurred on July 6, 1982.

For people in the Americas, the west coast offers the best view of the eclipse. Observers there can see a good portion of totality before the Moon sets. Most people in the western half of the United States can see at least some of the early, partial phases of the eclipse, but from the eastern half of the nation, the Moon sets before the eclipse begins.

The Moon begins to enter the nearly imperceptible, outer part of Earth's shadow, called the penumbra, at 3:11 a.m. Pacific Daylight Time (PDT). Just an hour after the Moon enters the penumbra, you'll notice a tiny dark notch on the Moon's western limb. This is the dark, inner part of Earth's shadow, or the umbra. It creeps across the Moon's face from 4:11 until 5:12 a.m. PDT, when totality begins. Those along the coast are destined to see a little less than half of totality. Shortly before mid-eclipse at 6:00 a.m. PDT, the Moon sinks into the Pacific Ocean as dawn breaks on the opposite side of the sky.

Your view of the eclipse improves the farther west you are. You can see the entire eclipse from Hawaii (totality runs from 2:12 to 3:49 a.m. local time), as well as from Australia, New Zealand, and eastern Asia.

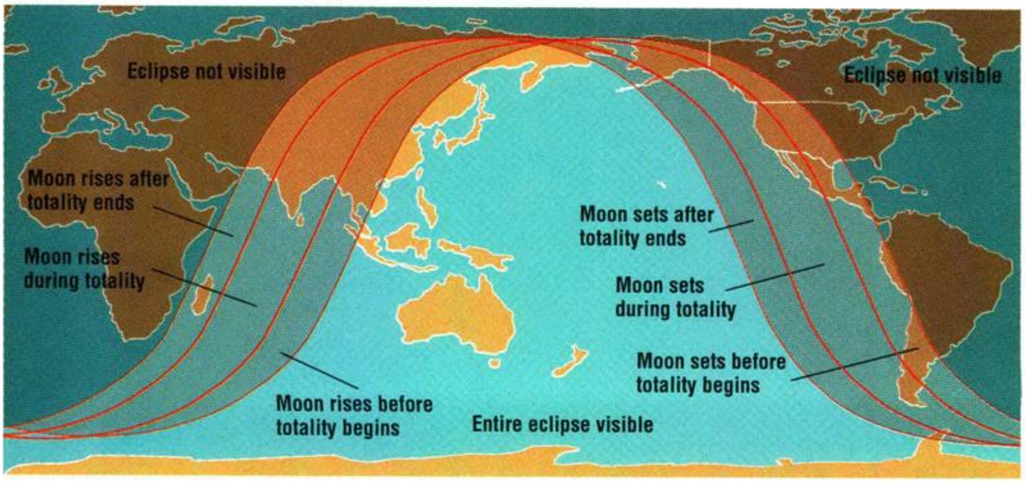
If you see totality, note how dark the Moon appears. The veiled face of the Moon generally takes on a reddish hue during totality because Earth's atmosphere preferentially filters out the other colors in sunlight and bends this reddened light into our planet's shadow. During last December's lunar eclipse, however, Earth's shadow appeared significantly darker than usual. That was courtesy of Mount Pinatubo, the volcano in the Philippines whose June 1991 eruption was the largest in the last 80 years. Pinatubo hurled a huge amount of debris into Earth's stratosphere, filtering out even more sunlight than the atmosphere normally does. This month's eclipse will help show how much volcanic debris remains up there, two years after the deadly eruption.

Mark Payne-Gill

THE MOON'S COLOR during totality can range from the coppery red displayed on August 17, 1989 (above) to the dark gray apparent in last December's eclipse. If you live where the June 4 total eclipse is visible (below), why not investigate what color the Moon offers this time?

VENUS PROMINENT IN THE MORNING SKY

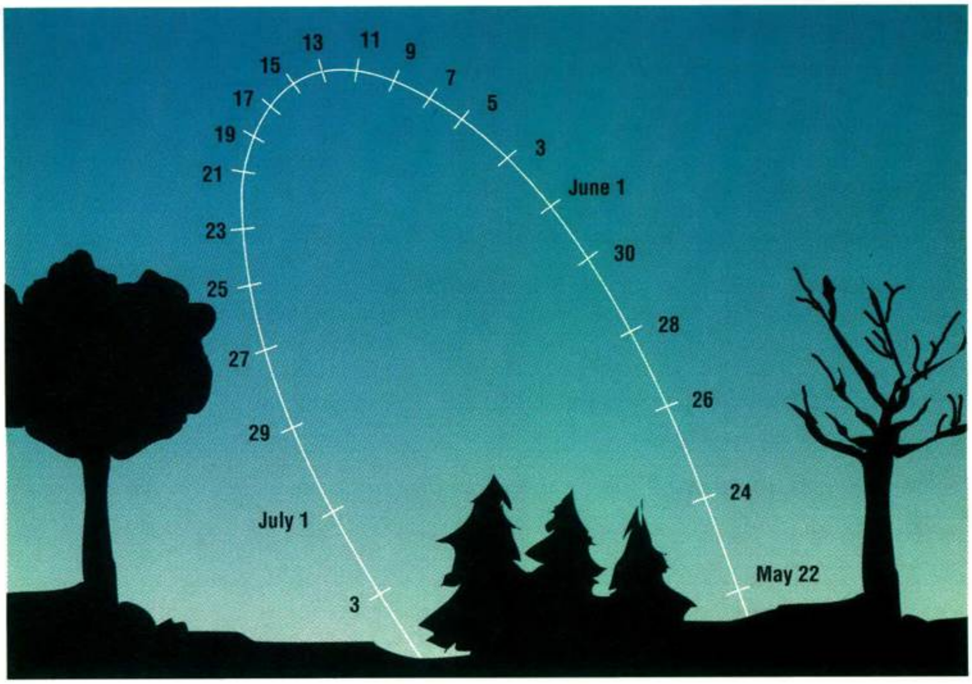
Brilliant Venus dominates the predawn sky this spring and summer. Last month the bright planet reached greatest brilliancy, shining at magnitude −4.5 in the east for nearly two hours before sunrise. This month Venus arrives at another significant milestone, reaching greatest elongation on June 10. On that morning it lies 46° west of the Sun, the farthest during this morning apparition. Though at magnitude −4.3 the planet appears slightly dimmer than it did last month, it's more conspicuous now because it rises earlier and appears farther from the light of the approaching dawn.


Eclipse not visible
Eclipse not visible
Moon rises after totality ends
Moon rises during totality
Moon rises before totality begins
Entire eclipse visible
Moon sets after totality ends
Moon sets during totality
Moon sets before totality begins

MERCURY'S BEST EVENING APPEARANCE

Mercury has a reputation for being hard to see, but it's actually easy to spot if you know just when and where to look. And this month is a good time, as the innermost planet is at its most visible for the entire year. Mercury reaches greatest elongation on June 17, when it lies 25° east of the Sun and shines at magnitude 0.6. But don't restrict your search to that date. From June 1 to June 22, Mercury lies between 10° and 13° above the west-northwestern horizon 30 minutes after the Sun sets. That's just a bit more than the width of your clenched fist held at arm's length. Scan the area with binoculars to get a fix on it, but once you know where Mercury is you should have no problem seeing it with your naked eye.

If you look for Mercury in early June, you'll notice two stars lying above the planet. These are Castor and Pollux, the brightest stars in the constellation Gemini. Evening by evening, the pair slowly sinks toward Mercury until by June 21 Pollux lies 7° north of the planet. On that same night, the waxing crescent Moon passes just 4° south of Mercury.



MERCURY CLIMBS into the evening sky this month, putting on its best show of the year. At its mid-June peak, an observer at 40° north latitude can see the planet 13° above the west-northwestern horizon 30 minutes after sunset.

JUNE'S PLANETS

The early evening sky this month offers something for every planet observer. There's Mercury, low in the west-northwest after sunset; Mars, somewhat fainter than Mercury but higher in the sky and easier to see; and Jupiter, the brightest by far and very conspicuous in the southwest.

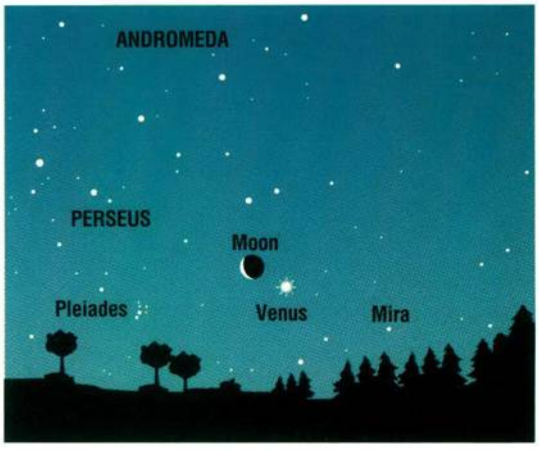
Mercury's excellent evening appearance peaks in mid-June, when the planet lies 13° high 30 minutes after sunset. But the most visually exciting event for Mercury watchers comes about a week later. On the evening of June 21, a slender crescent Moon passes 4° south of the planet. The pair remains visible well into the long, twilit evening, setting some 90 minutes after the Sun does.

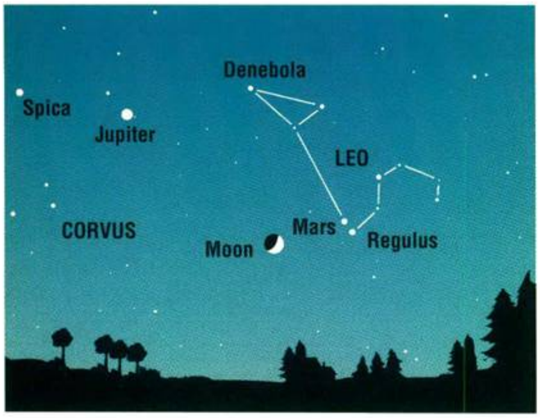
Ruddy **Mars** hovers above Mercury in the western twilight sky, setting nearly four hours after the Sun. The Red Planet appears dramatically dimmer than it did this past winter. In fact, it would be easy to overlook if not for its nearness to one of the sky's brightest stars, blue-white Regulus in the constellation Leo. Mars moves eastward through Leo this month, passing just 0.8° north of Regulus on the night of June 21/22. Mars then shines at magnitude 1.5 from a distance of about 16 light-minutes, while Regulus shines at nearly the same brightness from a distance of 85 light-years. Two nights later, on June 24, the waxing crescent Moon passes near the ruddy chunk of rock and blazing stellar furnace.

Jupiter lies high in the southwest as evening twilight deepens. You can't miss it — it's far brighter than any other point of light visible in this month's evening sky. The cream-colored planet shines at magnitude –2.1 among the background stars of Virgo.

Golden **Saturn** rises in the east about the same time Mars sets in the west. By the time morning twilight commences, it is prominent in the southeast — a steady light in the constellation Aquarius. The ringed planet shines at magnitude 0.8, much brighter than its surrounding stars, and is destined to grow brighter as it heads toward opposition in August.

VENUS PULLS AWAY from the Sun in June, reaching greatest elongation in the morning sky on the 10th. Six days later the waning crescent Moon pulls close to Venus, passing 6° away in the predawn sky.





MARS CRAWLS toward Regulus in the evening sky this month, passing within 1° of it in late June. On June 24, the ruddy planet and white star lie low in the west, near the waxing crescent Moon.

Only one planet appears in the east before dawn, but since it shines at magnitude –4.3, you can't miss it. **Venus** reaches its greatest elongation west of the Sun on June 10, when it rises just before morning twilight begins. Surprisingly, however, Venus continues climbing higher in the predawn sky for nearly two more months. The ecliptic — the apparent path of the Sun, Moon, and planets across the sky — makes a shallow angle with the eastern horizon at dawn this time of year. As summer progresses this angle increases, pushing Venus higher in our sky despite its being closer to the Sun.

THE STARRY SKY

This month's lunar eclipse takes place in the constellation Scorpius the Scorpion. On eclipse night, the Moon stands less than 4° from the brightest star in Scorpius, orange-red Antares. When the Moon moves away from the Scorpion over the following nights, you can see a curved line of stars dangling from Antares. It takes only a little imagination to see a scorpion's curved tail in these stars. Two stars lie at the tip of the Scorpion's tail. The brighter one is called Shaula, which means "stinger."

In Greek mythology, the Scorpion's sting killed the mighty hunter Orion. Afterward, the Hunter and Scorpion were kept as far away as possible, which is why they appear on opposite sides of the sky.

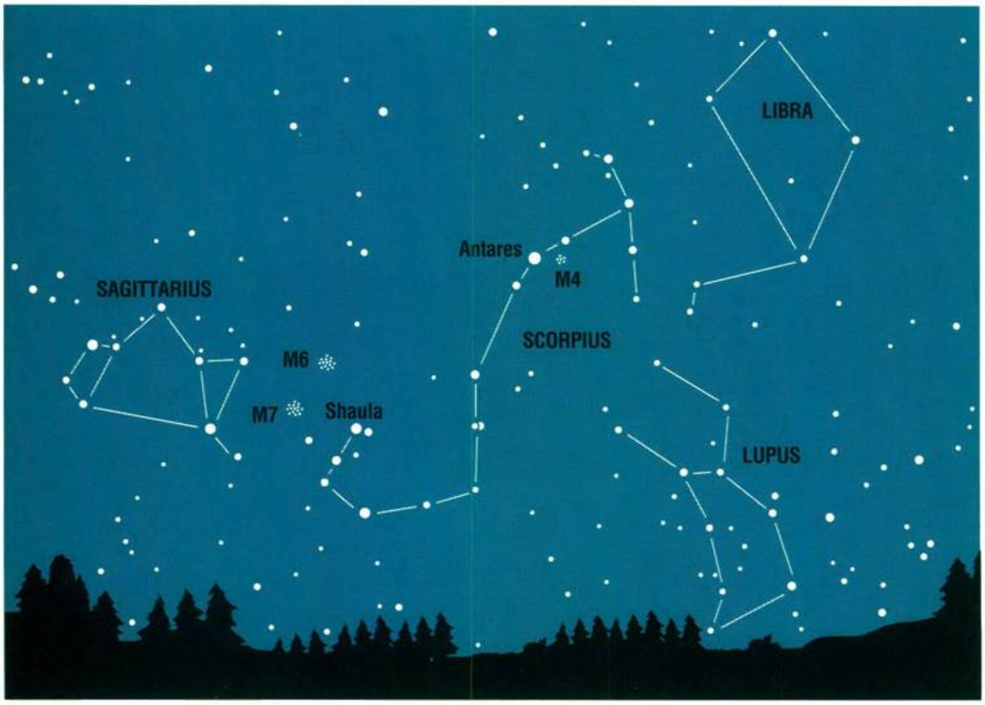
The stars of Scorpius lie in a wondrous region of the heavens. They are adjacent to the broadest and brightest part of the starlit trail of the Milky Way, not far from the direction to the galactic center. Many good binocular targets will tempt you here. Just 1° west of Antares is the globular star cluster M4. Under a dark sky, you can spot M4 with your naked eye, and binoculars will reveal it as a soft-edged patch of haze. The same can be said of two open star clusters — M6 and M7 — which lie about 5° northeast of the Scorpion's tail.

Antares' ruddy color inspired its name, which means "Rival of Mars." It shines at magnitude 1.0 across a distance of more than 300 light-years. It is a red supergiant star of enormous dimensions. If Antares replaced the Sun, its outer layers would engulf the planet Mars. Yet the star's huge volume makes its density very low — a million times less than that of the Sun.

Twinkling red Antares inevitably draws the eye on a summer evening as it arcs across the southern sky. It seems as much a part of summer as ice cream and long trips in the family car. Not everyone associates Scorpius with summer, however. South of the equator, Scorpius now rides high in the *northern* sky, passing nearly overhead around midnight. But those residents aren't enjoying the view under warm summer breezes. More likely they're huddled in overcoats, braced against the chilly winds of the current Southern Hemisphere winter. ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. It now can be heard on over 200 stations.

SCORPIUS THE SCORPION stands due south late on June evenings. Highlights of this constellation include bright, ruddy Antares and the scorpion's long, curved tail, whose stinger is marked by Shaula.



Through the Eyepiece ***by Rick Shaffer***

THE MOON IN EARTH'S SHADOW

On June 4 the Moon slips into Earth's shadow and observers will witness a total lunar eclipse. The best views of the eclipse will come to observers in Hawaii, Australia, New Zealand, Japan, and eastern Asia, where the entire eclipse can be seen. In the western half of North America, the Moon sets during the eclipse (at dawn on the 4th), though people along the west coast and in southern Alaska can see the first part of totality. (See the map on page 48 to find out how much of the eclipse is visible from your location.) To see as much of the eclipse as possible, choose a site with an unobstructed horizon toward the west-southwest, the direction in which the Moon sets.

With nice weather a distinct possibility in early June, you might want to invite your friends and neighbors to watch the eclipse with you. You can give your guests a good general view of the eclipse by using 10x70 or 11x80 binoculars mounted on a tripod. If you can, use a tripod that lets you raise and lower the central column to accommodate viewers of different heights. To show lunar craters as Earth's shadow moves across them, a telescope at a power of 100x to 175x works well.

Even when the Moon is completely immersed in the darker part of Earth's shadow, called the umbra, a faint illumination plays on the lunar surface. This happens because Earth's atmosphere slightly bends, or refracts, sunlight passing through it, which partially fills in the shadow. Red light passes through large quantities of air more easily than blue light does, so the sunlight that reaches the totally eclipsed Moon is predominantly red. (This also explains why the Sun appears red when it rises or sets.)

Two factors should make this a dark eclipse. First, the Moon passes deep into the umbra. At mid-eclipse the Moon's center lies less than 10' north of the center of Earth's shadow and the Moon's northern limb lies 18' from the edge of the umbra. This means the northern limb of the Moon may well display a reddish cast while the rest of the lunar disk appears quite dark.

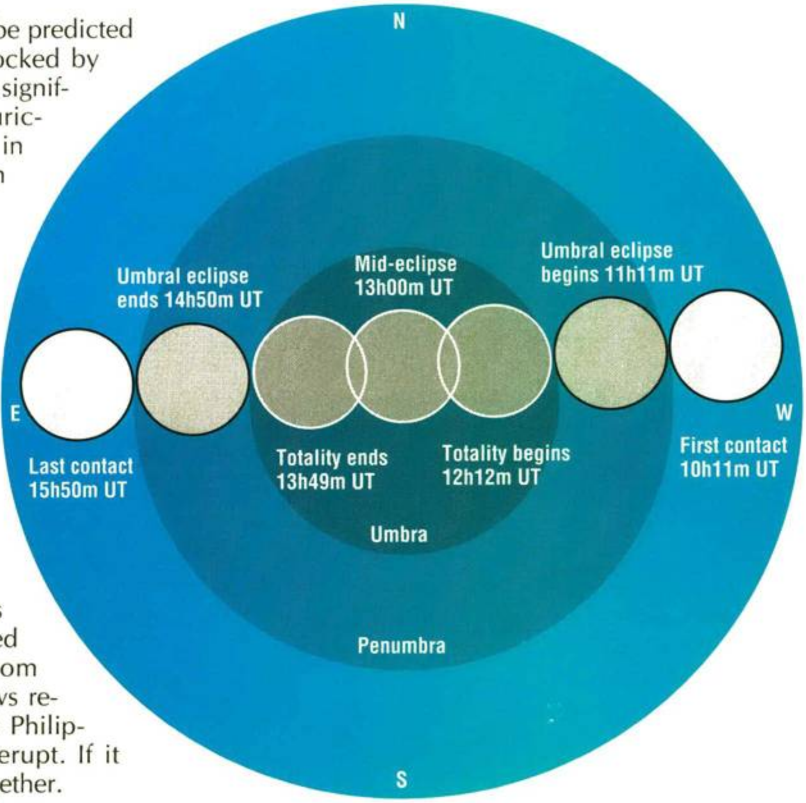
The second factor — and one that can't be predicted precisely — is the amount of sunlight blocked by clouds, dust, and volcanic debris. The most significant element here is the amount of sulfuric-acid aerosols and volcanic ash remaining in the atmosphere from the explosive eruption of Mount Pinatubo in the Philippines two years ago. Although this debris causes only a tenth of a magnitude attenuation in starlight reaching Earth's surface, sunlight on its way to the Moon during an eclipse passes through several hundred miles of this debris and can be attenuated by five or more magnitudes!

No one knows for sure how much of Pinatubo's debris remains in our atmosphere, but you can expect this "natural pollution" to make the Moon appear at least somewhat darker than normal. (That's what happened on June 14/15 and December 9/10, 1992, when Earth's shadow was dark enough that the eclipsed part of the Moon nearly disappeared from view.) And as I write this in February, news reports indicate that another volcano in the Philippines, named Mayon, may be ready to erupt. If it does, we could lose sight of the Moon altogether.

CRATER CROSSINGS

Crater	Enters Shadow	Leaves Shadow
Grimaldi	11h12m	13h53m
Billy	11h17m	13h59m
Aristarchus	11h21m	13h54m
Kepler	11h21m	13h59m
Campanus	11h27m	14h10m
Copernicus	11h29m	14h06m
Pytheas	11h30m	14h04m
Timocharis	11h35m	14h06m
Tycho	11h36m	14h18m
Plato	11h42m	14h04m
Manilius	11h44m	14h19m
Dionysius	11h48m	14h26m
Menelaus	11h48m	14h22m
Eudoxus	11h51m	14h14m
Aristoteles	11h51m	14h12m
Plinius	11h52m	14h26m
Goclenius	12h00m	14h40m
Taruntius	12h02m	14h38m
Proclus	12h02m	14h35m
Langrenus	12h05m	14h45m

THE LONGEST LUNAR ECLIPSE in 11 years occurs on June 4, when the Moon passes near the center of Earth's shadow (below). Use the table to follow the shadow's progress across lunar craters. (All times are in UT; subtract 4 hours to convert to EDT, 5 hours for CDT, 6 hours for MDT, and 7 hours for PDT.)



SPOTLIGHT ON JUPITER

Jupiter spends the month of June among the stars of Virgo, slowly growing fainter and smaller in apparent size. On the 1st, the giant planet measures 39.7" across its equator (slightly smaller across its poles) and shines at magnitude –2.2. By the end of the month, Jupiter shrinks to 36.5" in equatorial diameter and shines at magnitude –2.0.

Jupiter reaches two milestones this month. The first comes on June 14/15, when Jupiter is at aphelion — the farthest point in its 12-year-long orbit of the Sun. On that day, Jupiter lies 507 million miles from the Sun. That, combined with the planet's being well past opposition now, is why Jupiter appears relatively small. But for backyard observers, the most interesting milestone this month occurs on June 27, when the giant planet is at quadrature and lies 90° east of the Sun.

Around quadrature, you can see Jupiter's phase more easily than at any other position in its orbit. Although Jupiter appears 99 percent lit this month, the planet's eastern limb looks less defined than the western limb. This is because the Jovian terminator — the line separating day from night on Jupiter — lies on clouds of ammonia ice crystals at the top of Jupiter's atmosphere. The clouds diffuse sunlight falling on them, so the terminator appears less sharp than the Martian and lunar terminators, which lie on solid surfaces.

At eastern quadrature Jupiter's shadow falls at its easternmost position with respect to the Jovian sphere. Thus eclipses of the Galilean satellites by Jupiter occur farther from the disk of the planet than at any other time. For Ganymede, in fact, we can see the satellite emerge from behind Jupiter (an occultation), travel a short distance, and then disappear into the planet's shadow. The diagram on the opposite page shows the solar system geometry that creates this effect.

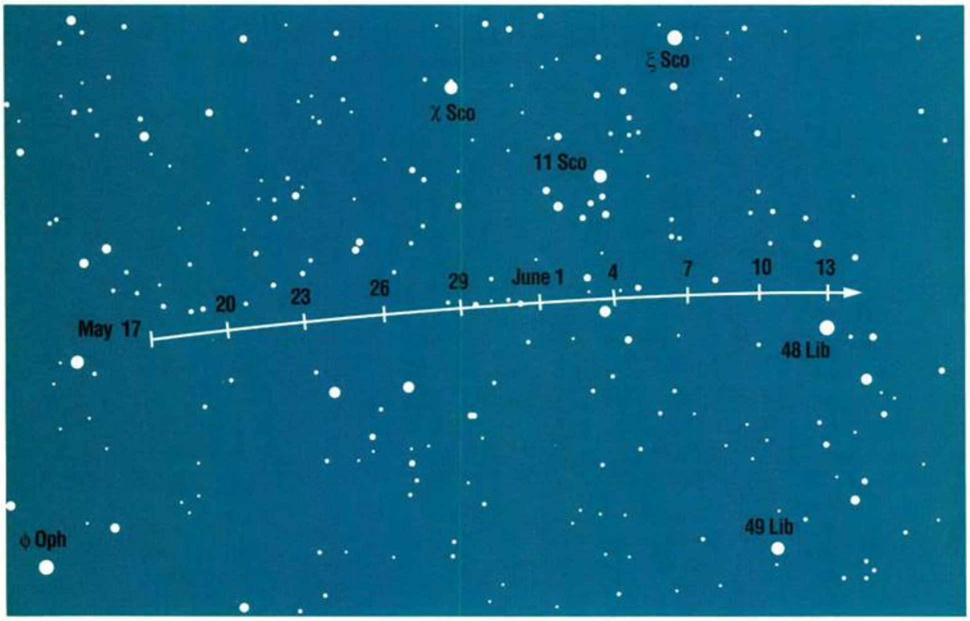
The best time for North American observers to view such an event this month occurs on the night of June 8/9. As Ganymede moves behind Jupiter, it vanishes behind the planet's western limb at 23h57m universal time on the 8th (7:57 p.m. EDT; 4:57 p.m. PDT) and reappears from behind the eastern limb at 2h51m UT on the 9th (10:51 p.m. EDT; 7:51 p.m. PDT on the 8th). You can then watch Ganymede pull away from Jupiter for two hours, only to disappear in eclipse at 4h57m UT (12:57 a.m. EDT; 9:57 p.m. PDT). Finally, it reemerges from eclipse at 7h39m UT (3:39 a.m. EDT; 12:39 a.m. PDT). Any observer in North America with a clear sky can see Ganymede disappear into Jupiter's shadow, although as seen from the eastern half of the continent Jupiter sets before the satellite reappears.

The table on the opposite page lists several other satellite events visible from North America during June. For Io, the closest of the Galilean satellites to Jupiter, an eclipse starts well before the satellite comes out from behind the planet's limb. Thus you'll see Io disappear behind the western limb of Jupiter and then reappear well off the eastern limb. The same is true of Europa for most of June, though at the very end of the month the satellite appears for a few minutes between an occulta-

COORDINATES FOR FLORA

Date	R.A. (2000)	Dec.
May 17	16h26.6m	–14°19'
May 20	16h23.4m	–14°14'
May 23	16h20.2m	–14°10'
May 26	16h16.9m	–14°06'
May 29	16h13.6m	–14°03'
June 1	16h10.3m	–14°00'
June 4	16h07.1m	–13°58'
June 7	16h04.0m	–13°56'
June 10	16h01.0m	–13°56'
June 13	15h58.1m	–13°56'

CATCH ASTEROID 8 FLORA as it traverses western Ophiuchus, northern Scorpius, and eastern Libra from mid-May to mid-June. Positions are shown for 11 p.m. EDT (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT).



tion and eclipse (none of these events are visible from North America, however). And finally, Callisto's orbit carries it too far south of Jupiter when it passes behind the planet, so it is neither eclipsed nor occulted.

TELESCOPIC PLANETS

This month **Mercury** is easier to see than at any other time this year, so don't miss it. You can begin looking for the planet after sunset in late May, when it is somewhat brighter (at magnitude –0.8) than it is in June but lies closer to the horizon. Mercury is easiest to see in mid-June, shortly before it reaches greatest eastern elongation on June 17. For an observer at 40° north latitude, the innermost planet then lies 13° above the west-northwestern horizon 30 minutes after the Sun goes down. Choose an observing site with an unobstructed horizon and use binoculars to spot Mercury initially.

The best aspect of observing Mercury with a telescope is watching the planet's phase and apparent size change. In late May the innermost planet appears 6" across and shows a distinctly gibbous phase; by greatest elongation it grows to 8" in apparent diameter and appears only 39 percent lit; and on June 30 it extends a full 10" across and displays a slender crescent just 17 percent lit.

Mercury isn't the only planet to reach greatest elongation this month. Our neighbor **Venus** does also, although this planet shines much brighter than Mercury at magnitude –4.3 and appears in the morning sky. This is the month to watch Venus' phase wax from crescent to gibbous. Geometry would suggest that the planet's dichotomy — when it appears exactly half-lit — should occur at greatest elongation on June 10. However, throughout history observers have noted that during morning appearances, dichotomy actually occurs a few days after greatest elongation. And the exact number of days seems to vary from apparition to apparition. If you want an intriguing observing project for June, follow Venus during the week following the 10th and see when it appears exactly half-lit to you.

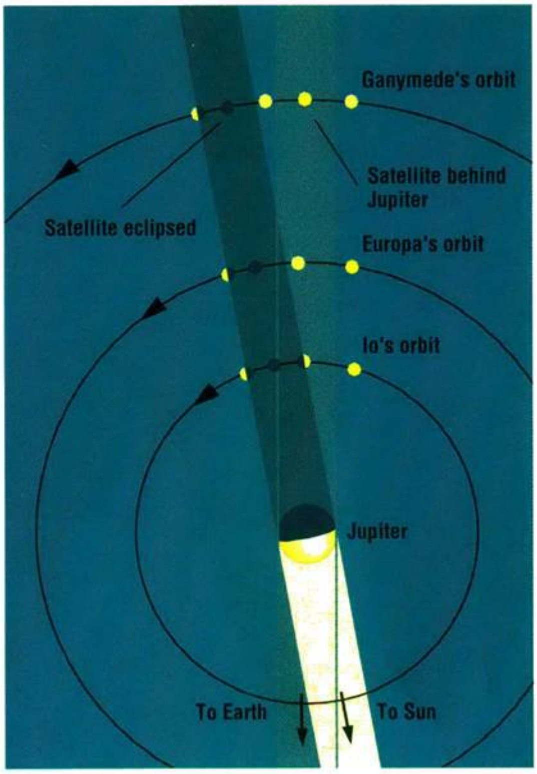
Mars is on the down side of its current apparition, appearing in the west for a few hours after twilight falls. The Red Planet shines at magnitude 1.5 and presents a 5"-diameter disk — barely large enough to see the north polar cap and a few dark markings. Your best view may come with a low-power eyepiece on the night of June 21/22, when Mars passes less than a degree north of the equally bright star Regulus in the constellation Leo.

Saturn rises around midnight and is high in the south when the Sun comes up. Because Saturn has a fairly low declination (–13°), it doesn't climb out of the murk at the horizon until a couple of hours before twilight begins. The 0.8-magnitude planet measures 18" across, while its glorious ring system spans 40".

ASTEROIDS IN THE EYEPIECE

The best asteroid this month is **8 Flora**, which actually reached opposition in late May. From mid-May to mid-June, this 150-kilometer-wide rock travels from western Ophiuchus through northern Scorpius into eastern Libra. Though relatively faint at about magnitude 9.5, you can spot the minor planet with the help of the chart or table of coordinates on the opposite page. □

Rick Shaffer is an engineer and writer in the aerospace industry in southern California.

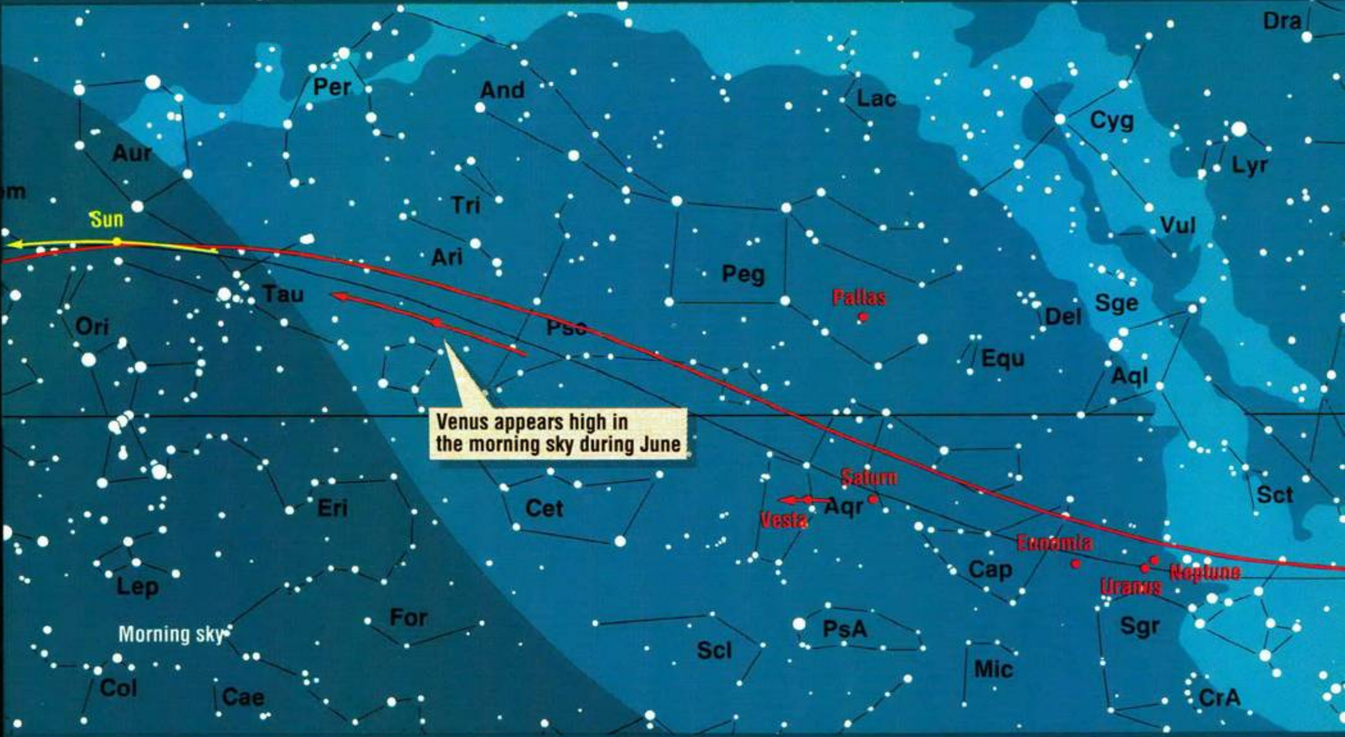


WATCH GANYMEDE DISAPPEAR into Jupiter's shadow on June 8/9. You can see the entire eclipse because Jupiter now casts its shadow far to one side of the planet's disk (above). This is just one of many intriguing phenomena of the Galilean satellites visible during June (below).

GALILEAN SATELLITE PHENOMENA

Date	Event	Universal Time
	IO	
June 2	Transit begins	3h51m
	Shadow enters	4h59m
	Transit ends	6h02m
	Shadow leaves	7h10m
June 10	Occultation begins	2h53m
	Eclipse ends	6h20m
June 18	Transit begins	2h03m
	Shadow enters	3h17m
	Transit ends	4h15m
	Shadow leaves	5h28m
	EUROPA	
June 18	Transit begins	0h52m
	Transit ends	3h23m
	Shadow enters	3h27m
	Shadow leaves	5h54m
	GANYMEDE	
June 8/9	Occultation begins	23h57m
	Occultation ends	2h51m
	Eclipse begins	4h57m
	Eclipse ends	7h39m

The Solar System June 1993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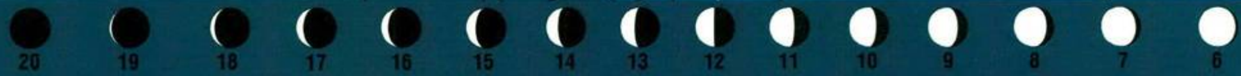
Venus appears high in the morning sky during June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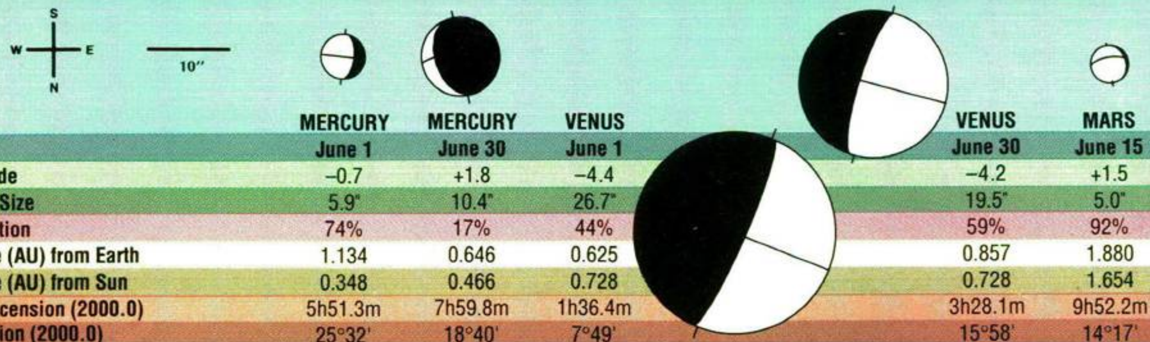
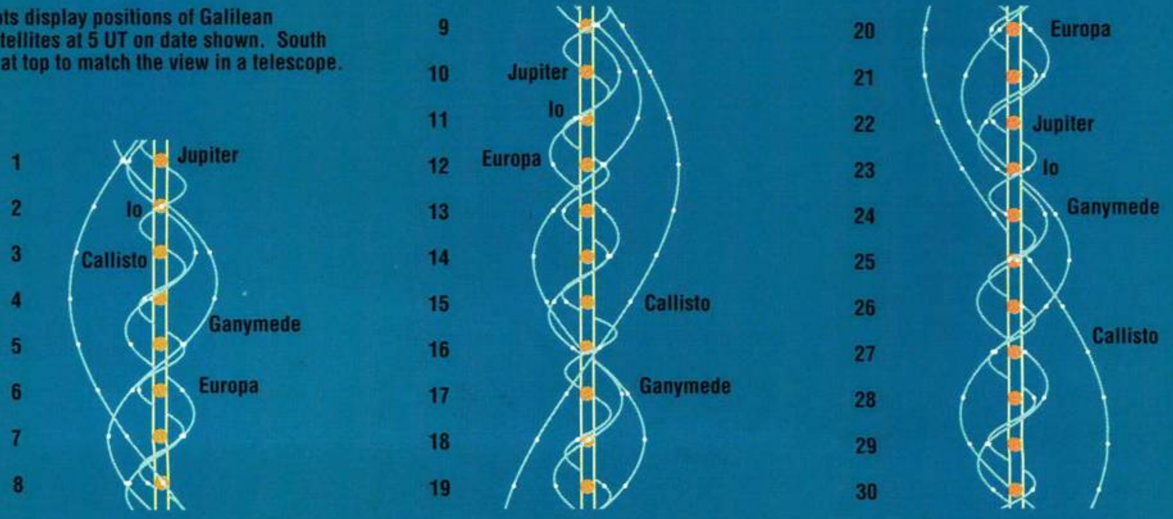
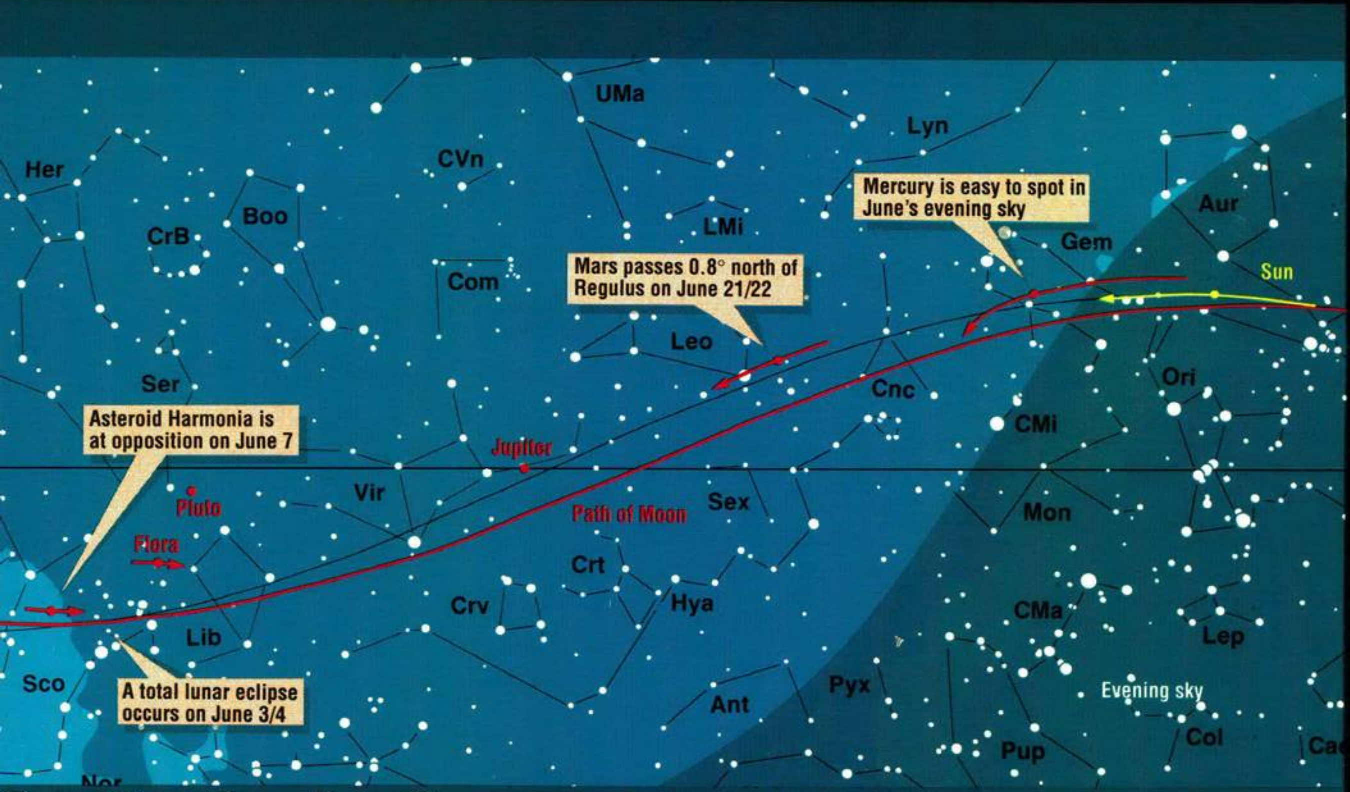


Planet	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	June 1	June 30	June 1	June 30	June 15
Magnitude	–0.7	+1.8	–4.4	–4.2	+1.5
Angular Size	5.9″	10.4″	26.7″	19.5″	5.0″
Illumination	74%	17%	44%	59%	92%
Distance (AU) from Earth	1.134	0.646	0.625	0.857	1.880
Distance (AU) from Sun	0.348	0.466	0.728	0.728	1.654
Right Ascension (2000.0)	5h51.3m	7h59.8m	1h36.4m	3h28.1m	9h52.2m
Declination (2000.0)	25°32′	18°40′	7°49′	15°58′	14°17′

Jupiter's Moons

Dots display positions of Galilean satellites at 5 UT on date shown. South is at top to match the view in a telescope.

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Crt
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Hya
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Lep
Sco
Pyx
Ant
Evening sky
Pup
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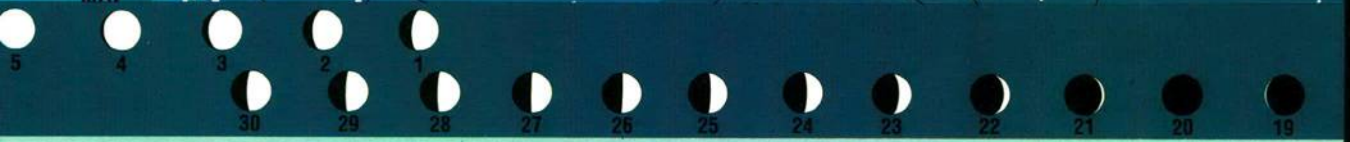
Mercury is easy to spot in June's evening sky

Mars passes 0.8° north of Regulus on June 21/22

Asteroid Harmonia is at opposition on June 7

A total lunar eclipse occurs on June 3/4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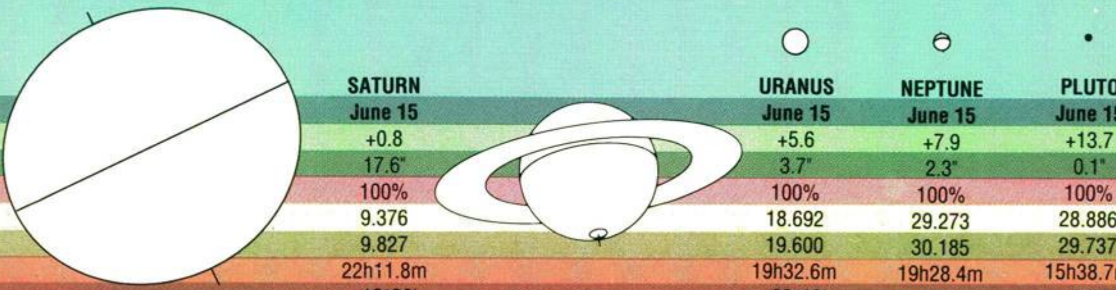
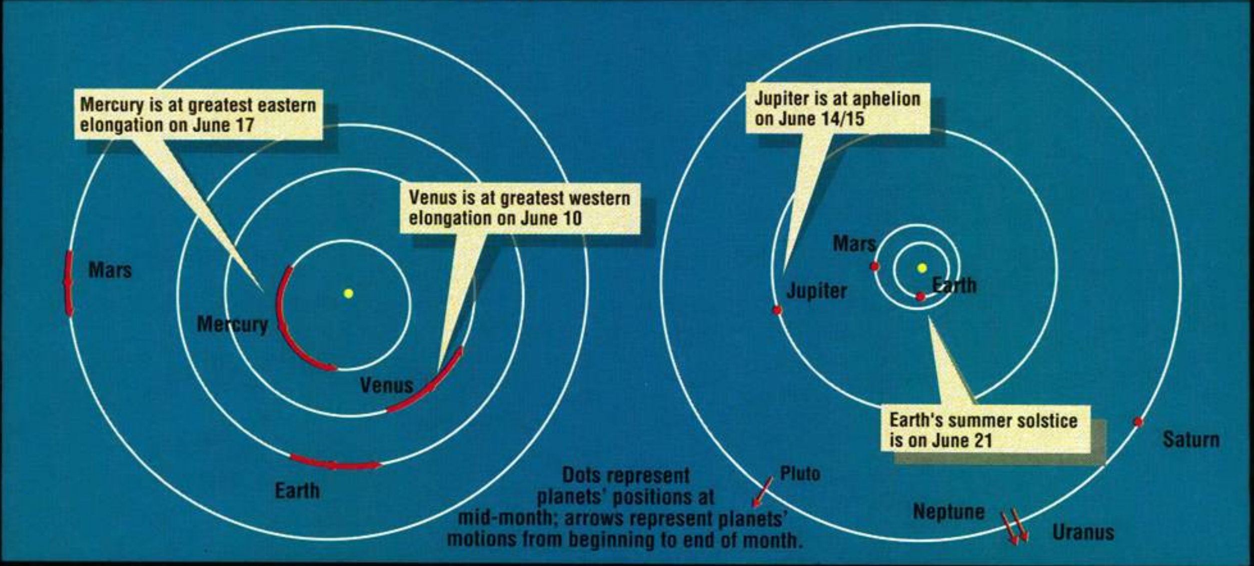


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
June 15	June 15	June 15	June 15	June 15
−2.1	+0.8	+5.6	+7.9	+13.7
38.1"	17.6"	3.7"	2.3"	0.1"
99%	100%	100%	100%	100%
5.166	9.376	18.692	29.273	28.886
5.454	9.827	19.600	30.185	29.737
12h21.0m	22h11.8m	19h32.6m	19h28.4m	15h38.7m
−0°47'	−12°36'	−22°13'	−21°11'	−4°19'

The Planets in Their Orbits


Mars
Mercury
Venus
Earth
Mars
Jupiter
Earth
Saturn
Pluto
Neptune
Uranus

Mercury is at greatest eastern elongation on June 17

Venus is at greatest western elongation on June 10

Jupiter is at aphelion on June 14/15

Earth's summer solstice is on June 21

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

CHOOSING EYEPIECES:
a buyer's guide

Can't tell an Ortho from an Erfle? Not to worry. We'll guide you through the marketplace of eyepieces and help you pick a set that's right for you.

by Alan Dyer

Happiness is a sparkling new eyepiece. Or better yet, a matching set of them. Eyepieces are the most important accessories you'll ever buy for your telescope. Although it is the main lens or mirror of your telescope that forms the image, it is the eyepiece that magnifies the image. And a good eyepiece does this without affecting image quality. With a set of fine eyepieces you'll be able to resolve all the celestial wonders your telescope is capable of revealing.

The Myth of High Power

To get the most out of your telescope, you should have three or four different eyepieces because on an astronomical telescope you switch magnification by switching eyepieces. The reason you change magnification is that celestial targets come in various sizes and brightnesses. A big object such as a sprawling cluster of stars is best framed with a low-power (25x to 50x) eyepiece. Inspecting details on a planet's tiny disk calls for a high-power (150x to 200x) eyepiece. Hunting galaxies or planetary nebulae might be best with a medium-power (80x to 120x) eyepiece.

The chief mistake new telescope owners make is to immediately insert the highest-power eyepiece they have in their arsenal. High-power eyepieces see only a tiny section of sky, making it frustrating to find even the Moon. Although newcomers sometimes feel compelled to buy an ultra-high-power model as their first extra eyepiece, a good low-power model is often a far wiser addition.

In fact, many entry-level telescopes sold through department and camera stores come with eyepieces that provide far too much magnification. How can you tell? If yours is one of the many imported 60mm refractors or 4.5-inch reflectors, chances are you'll find the tops of the eyepieces marked with designations such as AH20, HM9, HM6, or SR4. The numbers indicate the focal length of the eyepiece in millimeters. The smaller the number the higher the power that eyepiece provides.

To determine the magnification an eyepiece produces with your telescope, first look for the focal length of the telescope. It will be a number between 500mm and 1,500mm marked on the tube or in the manual. Take this number and divide it by the focal length of the eyepiece. For example, a 4mm eyepiece on a 900mm-focal-length telescope gives 225 power (900 ÷ 4), or 225x for short. That same eyepiece on a 1,500mm-focal-length scope will give 375x.

A figure of 375x sounds terrific. It's not. Although your import telescope may boast three or four eyepieces, the 6mm and 4mm models produce so much magnification that images through them look faint and fuzzy. Under the best conditions (using good optics in a steady atmosphere), the highest power you can usually employ on any telescope is about 50x to 60x per inch of aperture. For a 60mm (2.4-inch) telescope this works out to a maximum power of 120x to 150x. On typical 60mm-aperture refractors with focal lengths of 700mm to 900mm, a 4mm eyepiece gives an excessive power of 175x to 225x. A 6mm eyepiece produces 120x to 150x, right at the upper limit. Under most conditions, you'll find these eyepieces of little use.

ASTRONOMY: Chris Becker

Compounding the problem is that many entry-level telescopes come with poor quality eyepieces. Even the lower-power 20mm and 12mm eyepieces often provide poor images. The worst offenders are the ones marked AH, HM, or SR. These letters refer to the optical design of the eyepiece (AH = Achromatic Huygenian, HM = Huygenian Mittenzwey, SR = Symmetric Ramsden). All are simple two- or three-element designs that add fringes of false color around images of bright objects and have narrow, tunnel-like fields of view. Far better are the Kellner, Modified Achromat, and Orthoscopic eyepieces that manufacturers such as Celestron, Meade, Orion, and Parks are now supplying with their entry-level telescopes.

aus JENA
PLÖSSL 25mm
FULLY COATED
MEADE SUPER WIDE ANGLE

EYEPIECE BARREL SIZES include (from left to right) the 0.965-inch size usually found on eyepieces included with economy import telescopes, the popular 1.25-inch size, and the 2-inch size used for low-power, wide-angle eyepieces.

ASTRONOMY: Darla Gawelski

Eyepiece Designs

We recommend replacing poor eyepieces as a first step to improving your telescope. But choosing eyepieces involves more than simply picking ones with suitable focal lengths. Eyepieces also come in various optical designs. "Design" means the number of lens elements, the types of lenses, and their arrangement.

The most economical eyepiece designs of good quality are the 3-element **Kellners** (a classic design sold by several manufacturers), Meade's **Modified Achromats**, and Edmund's **RKE** line. These affordable eyepieces are the very minimum you should consider when choosing a budget set.

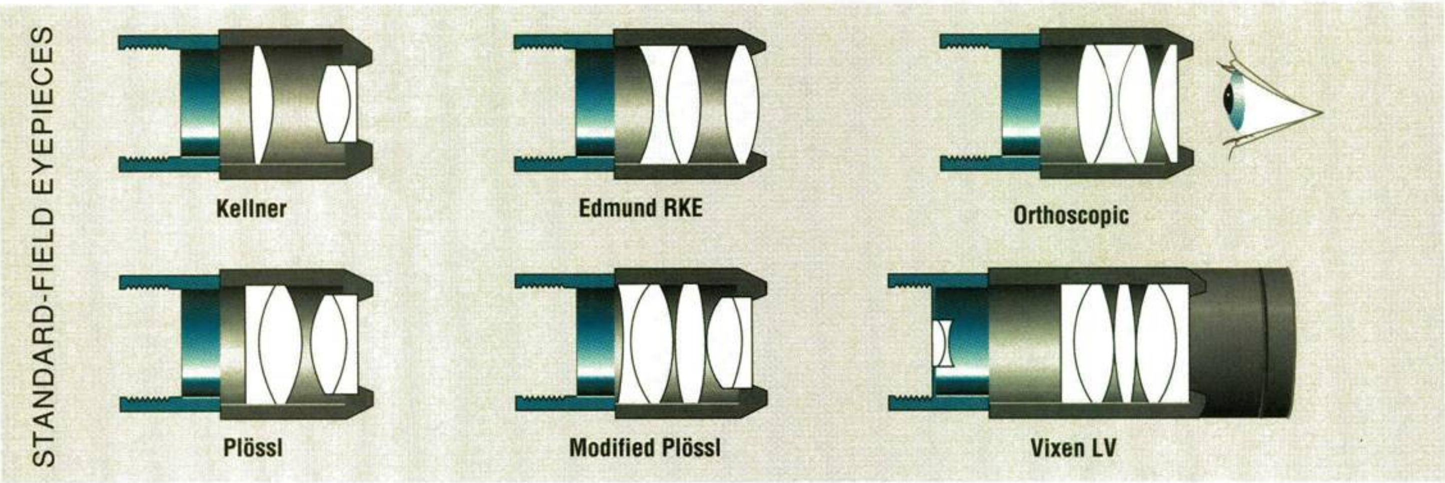
The next step up is to an **Orthoscopic**. Although "orthoscopic" can mean any highly corrected eyepiece, the term usually refers to a specific design invented in 1880 by Ernst Abbé, an optician with Zeiss in Jena, Germany. Orthos contain four elements and correct optical aberrations better than 3-element designs do. Orthos are fine eyepieces for viewing the planets.

In recent years, the 4-element **Plössl** has become very popular. It boasts a slightly wider field than most Orthos and a similar freedom from aberrations such as false color. It is a good general-purpose eyepiece capable of providing high-contrast planetary views.

Although not an officially sanctioned term, **Modified Plössl** is our name for a new family of eyepieces which adds a fifth element between the Plössl's two pairs of lenses. Examples include Celestron's Ultima line, Meade's Super Plössls, Orion's Ultrascopics, and both Parks' and Roger Tuthill's premium Plössl series. All provide superb color correction, sharp on-axis images, and excellent suppression of ghost images, the term for annoying internal reflections of bright stars and planets.

The new **Vixen Lanthanum LV** design has a 5-element Modified Plössl at its heart, but on high-power

the glass menagerie



Kellner

Edmund RKE

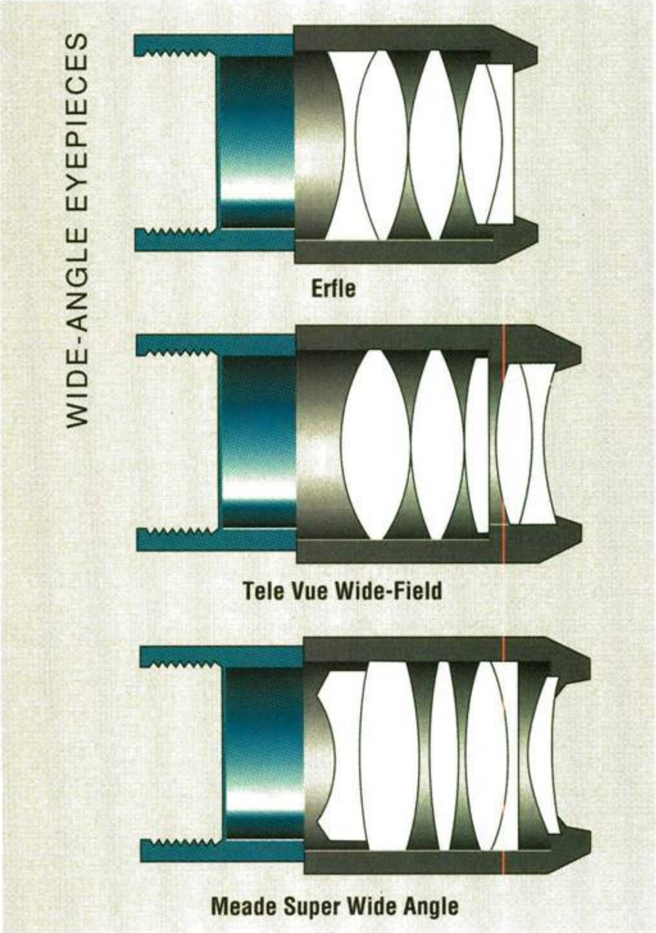
Orthoscopic

Plössl

Modified Plössl

Vixen LV

STANDARD-FIELD EYEPIECES provide apparent fields of 40° to 50° and come in a variety of optical designs. Some of these designs, such as the Kellner, Orthoscopic, and Plössl, were invented many years ago and are available from a number of suppliers. Others, such as the RKE and LV eyepieces, are new proprietary designs of specific manufacturers. Modified Plössl is a generic name for several brands of new 5-element eyepieces.

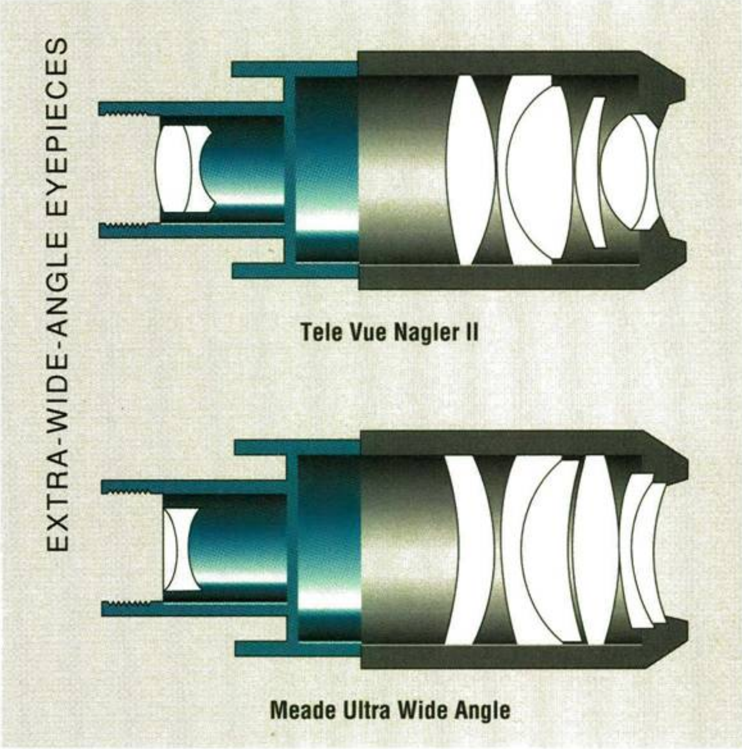


Erfle

Tele Vue Wide-Field

Meade Super Wide Angle

WIDE-ANGLE EYEPIECES employ up to 6 or 7 lens elements *and boast apparent* fields of 60° to 70°, making them ideal for deep-sky viewing. The Erfle design was invented during World War II for military use. Long popular with amateur astronomers, it has now been replaced by newer proprietary designs that exhibit few or no ghost images and decreased levels of off-axis astigmatism.

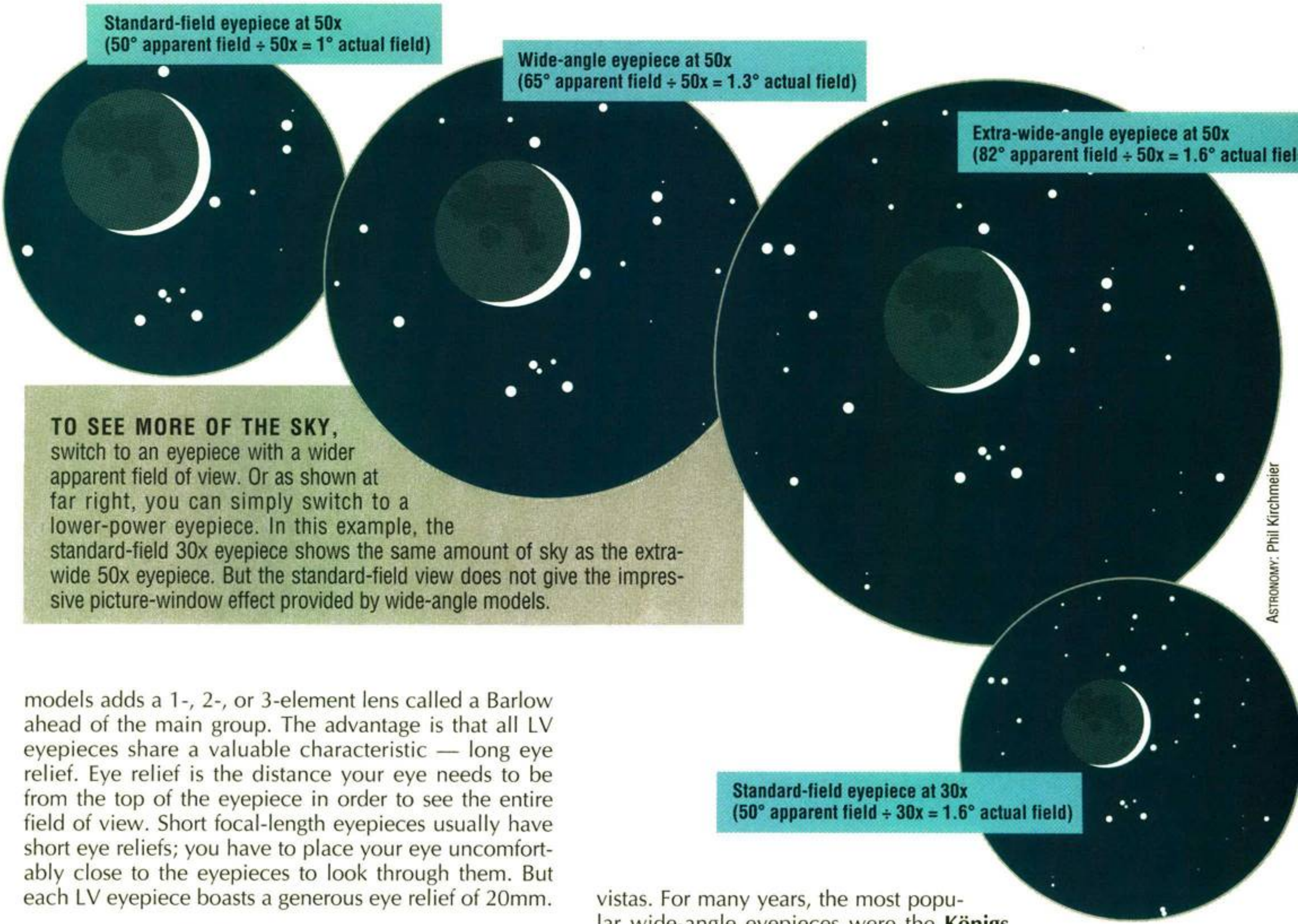


Tele Vue Nagler II

Meade Ultra Wide Angle

ASTRONOMY: Phil Kirchmeier

EXTRA-WIDE-FIELD EYEPIECES, such as Tele Vue's patented Nagler and Nagler II series and Meade's Ultra Wide Angle models, contain complex and costly sets of optics but provide the finest images over the widest fields (up to 84°) of any eyepiece available. In 20mm to 13mm focal lengths, they are also among the largest and heaviest eyepieces on the market. But many backyard astronomers find the views through these eyepieces difficult to resist.


Standard-field eyepiece at 50x
(50° apparent field ÷ 50x = 1° actual field)
Wide-angle eyepiece at 50x
(65° apparent field ÷ 50x = 1.3° actual field)
Extra-wide-angle eyepiece at 50x
(82° apparent field ÷ 50x = 1.6° actual fiel
Standard-field eyepiece at 30x
(50° apparent field ÷ 30x = 1.6° actual field)

TO SEE MORE OF THE SKY, switch to an eyepiece with a wider apparent field of view. Or as shown at far right, you can simply switch to a lower-power eyepiece. In this example, the standard-field 30x eyepiece shows the same amount of sky as the extra-wide 50x eyepiece. But the standard-field view does not give the impressive picture-window effect provided by wide-angle models.

ASTRONOMY: Phil Kirchmeier

models adds a 1-, 2-, or 3-element lens called a Barlow ahead of the main group. The advantage is that all LV eyepieces share a valuable characteristic — long eye relief. Eye relief is the distance your eye needs to be from the top of the eyepiece in order to see the entire field of view. Short focal-length eyepieces usually have short eye reliefs; you have to place your eye uncomfortably close to the eyepieces to look through them. But each LV eyepiece boasts a generous eye relief of 20mm.

Wide-Angle Eyepieces

All the eyepieces described so far provide a standard field of view. There is another group of eyepiece designs that provides wide fields of view.

To determine an eyepiece's field of view look in the accompanying tables for the column labeled "apparent field of view FOV (°)." To see what this number refers to, hold an eyepiece up to your eye and aim it at the sky or at a window. You'll see a circle of light. The angular diameter of that circle is the eyepiece's apparent field. Standard-field eyepieces have apparent fields of 40° to 50°. Wide-angle models have apparent fields of 60° to 70°. A new generation of eyepieces we've dubbed "extra-wide-angle" models have apparent fields around 80° across.

But a number such as 80° doesn't mean you see 80° of sky when you look through that eyepiece on your telescope. How much sky you see is called the "actual field of view." To determine the approximate actual field of an eyepiece, divide its apparent field by the magnification that particular eyepiece provides on your telescope. For example, an eyepiece with a 50° apparent field which produces 50x will show you 50 ÷ 50 = 1° of sky. An 80° apparent-field eyepiece that also produces 50x on your scope will show you 80 ÷ 50 = 1.6°. The magnification hasn't changed, but with the 80° eyepiece you see more of the sky.

Wide-angle eyepieces provide impressive picture-window views of starfields, deep-sky objects, and lunar vistas. For many years, the most popular wide-angle eyepieces were the **Königs** (a 3- or 4-element design) and **Erfles** (a 5- or 6-element design). The König provides a wide apparent field of about 60° to 65° at a relatively affordable price. University Optics offers a fine series of Königs in a wide range of focal lengths. Erfles are available from a few suppliers but this economical design has now been overshadowed by newer eyepieces carrying the trade names of various manufacturers. The new designs provide improved image quality toward the edge of the field and few or no ghost images.

For example, Tele Vue's **Wide Field** and Meade's **Super Wide Angle** eyepieces are both 6-element designs with apparent fields of 65° to 67°. Both series offer low- to medium-power focal lengths and are excellent choices for deep-sky and general-purpose viewing, especially with f/6 to f/15 telescopes. Another wide-angle variation, Orion's **MegaVista**, is a 7-element eyepiece available in focal lengths from 40mm to 10.5mm. It provides freedom from ghost images and a 67° to 70° field at an economical price.

Although superb performers, all of these wide-angle designs still exhibit some traces of an aberration called astigmatism, which turns stars at the edge of the field from ideal pinpoints into fuzzy, elongated streaks. All eyepieces exhibit more astigmatism when used on fast telescopes, ones with focal ratios of f/4 to f/6. However, in the last few years, designers have created eyepieces that produce almost pinpoint stars

(continued on p. 64)

the eyepiece marketplace

Economy Eyepieces — 0.965-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Celestron	Kellner	40	35	C	25	—	—	$54
Celestron	Kellner	30	40	C	20	—	—	$54
Celestron	Kellner	25	42	C	16	—	—	$54
Celestron	Kellner	18	42	C	12	—	—	$54
Celestron	Kellner	10	43	C	9	—	—	$54
Celestron	Orthoscopic	12	43	FMC	9	—	—	$60
Celestron	Orthoscopic	9	40	FMC	7	—	—	$60
Celestron	Orthoscopic	7	41	FMC	5	—	—	$60
Celestron	Orthoscopic	6	43	FMC	4	—	—	$60
Edmund	Kellner	25	39	C	n/a	—	—	$49
Edmund	Kellner	18	46	C	n/a	—	—	$49
Edmund	Kellner	12	38	C	n/a	—	—	$49
Edmund	Kellner	9	45	C	n/a	—	—	$49
Edmund	Kellner	6	40	C	n/a	—	—	$49
Meade	Modified Achr.	40	36	C	18	—	—	$35
Meade	Modified Achr.	25	40	C	16	—	—	$35
Meade	Modified Achr.	12	40	C	8	—	—	$35
Meade	Modified Achr.	9	40	C	6	—	—	$35
Orion	Achr. Huygen.	40	30	MC	14	—	—	$34
Orion	Kellner	25	38	MC	15	—	√	$34
Orion	Kellner	18	38	MC	10	—	—	$34
Orion	Orthoscopic	12.5	40	MC	9	—	√	$47
Orion	Orthoscopic	9	44	MC	6	—	√	$47
Orion	Orthoscopic	7	44	MC	5	—	√	$47
Orion	Orthoscopic	5	44	MC	5	—	√	$47
Tuthill	Orthoscopic	25	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	18	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	12.5	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	9	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	7	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	6	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	5	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	4	n/a	C	n/a	—	√	$55

Premium Standard-Field — 0.965-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Takahashi	Orthoscopic	40	40	FMC	n/a	√	n/a	$160
Takahashi	Orthoscopic	25	42	FMC	n/a	√	n/a	$115
Takahashi	Orthoscopic	18	45	FMC	n/a	√	n/a	$105
Takahashi	Orthoscopic	12.5	42	FMC	n/a	√	n/a	$105
Takahashi	Orthoscopic	9	40	FMC	n/a	√	n/a	$105
Takahashi	Orthoscopic	7	40	FMC	n/a	√	n/a	$105
Takahashi	Orthoscopic	5	40	FMC	n/a	√	n/a	$105
Takahashi	High Eyepoint	4	40	FMC	n/a	√	n/a	$115
Takahashi	High Eyepoint	2.8	40	FMC	n/a	√	n/a	$135
Zeiss Jena	Orthoscopic	25	40	C	20	—	√	$165
Zeiss Jena	Orthoscopic	16	40	C	13	—	√	$165
Zeiss Jena	Orthoscopic	12.5	40	C	10	—	√	$165
Zeiss Jena	Orthoscopic	10	40	C	8	—	√	$165
Zeiss Jena	Orthoscopic	6	40	C	5	—	√	$165
Zeiss Jena	Orthoscopic	4	40	C	3	—	√	$165

Economy Eyepieces — 1.25-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Adorama	Pro-Optic Plössl	25	46	C	20	—	√	$42
Adorama	Pro-Optic Plössl	17	46	C	13	—	√	$42
Adorama	Pro-Optic Plössl	10	46	C	6	—	√	$42
Adorama	Pro-Optic Plössl	7.5	46	C	4	—	√	$42
Edmund	RKE	28.7	45	C	25	√	√	$50
Edmund	RKE	21.5	45	C	19	—	√	$50
Edmund	RKE	15	45	C	13	—	√	$50
Edmund	RKE	12	45	C	11	—	√	$50
Edmund	RKE	8	45	C	8	—	√	$50
Meade	Modified Achr.	40	36	MC	18	—	—	$38
Meade	Modified Achr.	25	40	MC	16	—	—	$38
Meade	Modified Achr.	12	40	MC	8	—	—	$38
Meade	Modified Achr.	9	40	MC	6	—	—	$38
Meade	Orthoscopic	25	45	MC	19	—	√	$48
Meade	Orthoscopic	12.5	45	MC	9	—	√	$48
Meade	Orthoscopic	9	45	MC	7	—	√	$48
Meade	Orthoscopic	6	45	MC	6	—	√	$48
Meade	Orthoscopic	4	45	MC	4	—	√	$48
Orion	Kellner	40	30	MC	14	—	√	$39
Orion	Kellner	25	40	MC	20	—	√	$39
Orion	Kellner	18	54	MC	15	—	√	$39
Orion	Kellner	12	40	MC	9	—	√	$39
Orion	Kellner	9	40	MC	7	—	√	$39
Orion	Kellner	6	40	MC	5	—	√	$39
Orion	Orthoscopic	25	41	MC	20	—	√	$50
Orion	Orthoscopic	18	45	MC	14	—	√	$50
Orion	Orthoscopic	12.5	40	MC	12	—	√	$50
Orion	Orthoscopic	9	44	MC	6	—	√	$50
Orion	Orthoscopic	7	44	MC	6	—	√	$50
Orion	Orthoscopic	5	44	MC	5	—	√	$50
Orion	Sirius Plössl	25	50	C	20	—	√	$60
Orion	Sirius Plössl	17	50	C	13	—	√	$60
Orion	Sirius Plössl	10	50	C	8	—	√	$60
Orion	Sirius Plössl	7.5	50	C	6	—	√	$60
Parks	Kellner	40	32	MC	n/a	—	—	$45
Parks	Kellner	25	42	MC	n/a	—	—	$45
Parks	Kellner	12	42	MC	n/a	—	—	$45
Parks	Kellner	6	42	MC	n/a	—	—	$45
Royal Optics	Plössl	25	50	C	20	—	√	$39
Royal Optics	Plössl	17	50	C	13	—	√	$39
Royal Optics	Plössl	10	50	C	8	—	√	$39
Royal Optics	Plössl	7.5	50	C	6	—	√	$39
University	Plössl	20	50	FMC	n/a	—	—	$50
University	Plössl	12	50	FMC	n/a	—	—	$50
University	Plössl	7	50	FMC	n/a	—	—	$50

Note: Models listed under "Economy Eyepieces" sell for $60 or less. Standard Field eyepieces selling for over $60 are listed as "Premium" models.

Premium Standard-Field — 1.25-inch Barrel

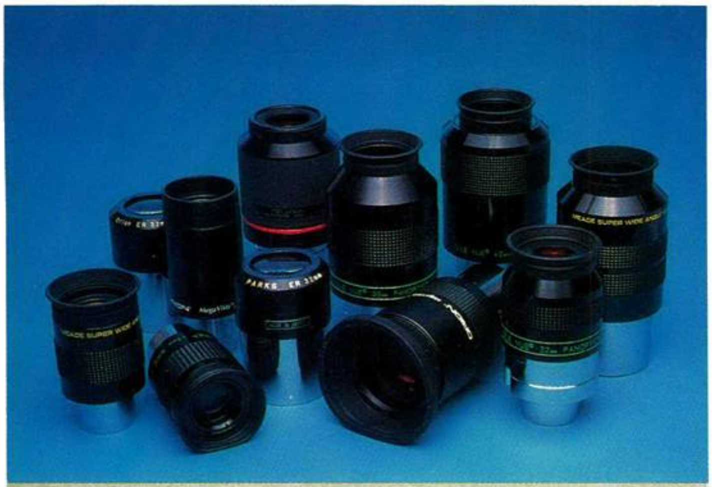
Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Celestron	Orthoscopic	12	42	FMC	11	—	—	$80
Celestron	Orthoscopic	9	40	FMC	8	—	—	$80
Celestron	Orthoscopic	7	40	FMC	6	—	—	$80
Celestron	Orthoscopic	6	40	FMC	5	—	—	$80
Celestron	Ultima	42	36	FMC	32	√	—	$125
Celestron	Ultima	35	49	FMC	25	√	—	$130
Celestron	Ultima	30	50	FMC	21	√	√	$105
Celestron	Ultima	24	51	FMC	18	√	√	$95
Celestron	Ultima	18	51	FMC	13	√	√	$90
Celestron	Ultima	12.5	51	FMC	9	√	√	$80
Celestron	Ultima	7.5	51	FMC	5	√	√	$80
Celestron	Ultima	5	50	FMC	4	√	√	$85
Celestron	Zoom	6.5-18	var.	MC	n/a	√	√	$120
Clavé	Plössl	20	50	FMC	n/a	—	√	$195
Clavé	Plössl	16	50	FMC	n/a	—	√	$195
Clavé	Plössl	12	50	FMC	n/a	—	√	$195
Clavé	Plössl	10	50	FMC	n/a	—	√	$195
Clavé	Plössl	8	50	FMC	n/a	—	√	$195
Clavé	Plössl	6	50	FMC	n/a	—	√	$195
Clavé	Plössl	5	50	FMC	n/a	—	√	$195
Clavé	Plössl	4	50	FMC	n/a	—	√	$195
Edmund	Orthoscopic	25	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	18	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	12.5	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	6	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	4	n/a	C	n/a	—	—	$70
Meade	Super Plössl	40	44	FMC	30	√	—	$110
Meade	Super Plössl	32	52	FMC	20	√	√	$110
Meade	Super Plössl	26	52	FMC	18	√	√	$88
Meade	Super Plössl	20	52	FMC	13	√	√	$88
Meade	Super Plössl	15	52	FMC	9	√	√	$88
Meade	Super Plössl	12.4	52	FMC	7	√	√	$88
Meade	Super Plössl	9.7	52	FMC	5	√	√	$88
Meade	Super Plössl	6.4	52	FMC	2	√	√	$88
Orion	Ultrascopic	35	52	FMC	25	—	—	$100
Orion	Ultrascopic	30	52	FMC	21	—	√	$90
Orion	Ultrascopic	25	52	FMC	17	—	√	$75
Orion	Ultrascopic	20	52	FMC	13	—	√	$70
Orion	Ultrascopic	15	52	FMC	10	—	√	$70
Orion	Ultrascopic	10	52	FMC	6	—	√	$70
Orion	Ultrascopic	7.5	52	FMC	5	—	√	$70
Orion	Ultrascopic	5	52	FMC	8	—	√	$90
Orion	Ultrascopic	3.8	52	FMC	6	—	√	$90
Parks	Gold Plössl	35	50	MC	n/a	—	—	$163
Parks	Gold Plössl	30	52	MC	n/a	—	√	$130
Parks	Gold Plössl	25	52	MC	n/a	—	√	$98
Parks	Gold Plössl	20	52	MC	n/a	—	√	$98
Parks	Gold Plössl	15	52	MC	n/a	—	√	$91
Parks	Gold Plössl	10	52	MC	n/a	—	√	$91
Parks	Gold Plössl	7.5	52	MC	n/a	—	√	$91
Parks	Gold Plössl	5	52	MC	n/a	—	√	$156
Parks	Gold Plössl	3.8	52	MC	n/a	—	√	$156

ADDING GOOD QUALITY 0.965-INCH EYEPIECES improves your import telescope. Economy models (left) are available for under $50; premium units (right) can cost over $100 each.

ECONOMY EYEPIECES (under $60 each) to fit 1.25-inch focusers are available from several manufacturers. A range of four makes a good core set that will cost $150 to $250.

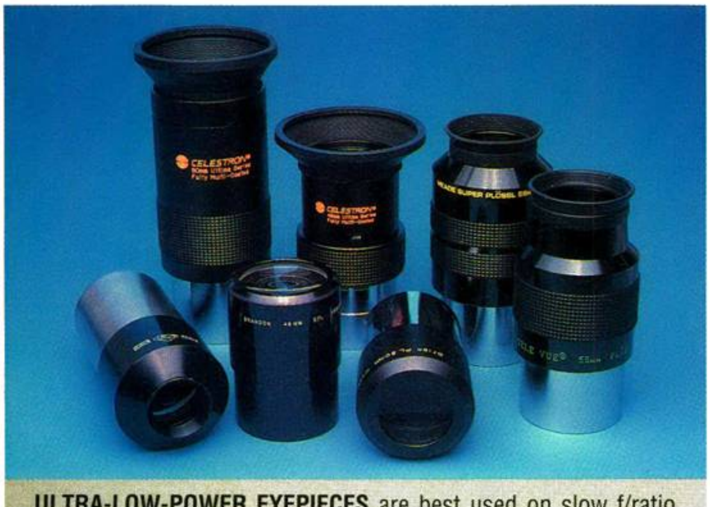
PREMIUM STANDARD-FIELD EYEPIECES offer top quality and a wide range of focal lengths to suit any telescope and observing interest. A core set of four will cost $280 to $600.

Astronomy: Darla Gawelski



WIDE-ANGLE EYEPIECES are available in 1.25-inch and 2-inch barrels. These can show you more sky than a standard-field eyepiece of the same focal length. Wide-angle models start at $75.

EXTRA-WIDE-ANGLE EYEPIECES provide stunning fields of view with pinpoint stars across the entire field. These models come in 1.25-inch, 2-inch, and dual-sized barrels that fit both sizes.



ULTRA-LOW-POWER EYEPIECES are best used on slow f/ratio telescopes (f/8 to f/16) for achieving the lowest power and brightest images possible.

ASTRONOMY: Darla Gawelski

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Tele Vue	Plössl	40	43	FMC	28	√	—	$110
Tele Vue	Plössl	32	50	FMC	22	√	√	$110
Tele Vue	Plössl	26	50	FMC	18	√	√	$90
Tele Vue	Plössl	21	50	FMC	14	√	√	$90
Tele Vue	Plössl	17	50	FMC	12	√	√	$90
Tele Vue	Plössl	13	50	FMC	9	√	√	$90
Tele Vue	Plössl	10.5	50	FMC	7	√	√	$90
Tele Vue	Plössl	7.4	50	FMC	5	√	√	$90
Tuthill	Orthoscopic	25	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	18	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	12.5	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	9	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	7	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	6	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	5	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	4	n/a	C	n/a	—	√	$65
Tuthill	Plössl	35	45	MC	n/a	—	√	$105
Tuthill	Plössl	30	50	MC	n/a	—	√	$90
Tuthill	Plössl	25	50	MC	n/a	—	√	$80
Tuthill	Plössl	20	50	MC	n/a	—	√	$80
Tuthill	Plössl	15	50	MC	n/a	—	√	$80
Tuthill	Plössl	10	50	MC	n/a	—	√	$80
Tuthill	Plössl	7.5	50	MC	n/a	—	√	$80
Tuthill	Plössl	5	50	MC	n/a	—	√	$85
University	König II	32	52	FMC	n/a	—	—	$100
VernonScope	Brandon	32	50	C	26	√	√	$125
VernonScope	Brandon	24	50	C	19	√	√	$125
VernonScope	Brandon	16	50	C	13	√	√	$125
VernonScope	Brandon	12	50	C	10	√	√	$125
VernonScope	Brandon	8	50	C	6	√	√	$125
Vixen	Lanthanum LV	25	50	FMC	20	√	√	$120
Vixen	Lanthanum LV	20	50	FMC	20	√	√	$120
Vixen	Lanthanum LV	15	50	FMC	20	√	√	$105
Vixen	Lanthanum LV	10	50	FMC	20	√	√	$105
Vixen	Lanthanum LV	9	50	FMC	20	√	√	$105
Vixen	Lanthanum LV	6	45	FMC	20	√	√	$105
Vixen	Lanthanum LV	5	45	FMC	20	√	√	$105
Vixen	Lanthanum LV	4	45	FMC	20	√	√	$120
Vixen	Lanthanum LV	2.5	45	FMC	20	√	√	$120

Wide Angle — 1.25-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Meade	Super Wide	24.5	67	FMC	19	√	√	$170
Meade	Super Wide	18	67	FMC	14	√	√	$150
Meade	Super Wide	13.8	67	FMC	10	√	√	$140
Orion	MegaVista	16.8	67	FMC	16	√	√	$120
Orion	MegaVista	10.5	67	FMC	13	√	√	$120
Tele Vue	Wide-Field	24	65	FMC	14	√	√	$185
Tele Vue	Wide-Field	19	65	FMC	11	√	√	$160
Tele Vue	Wide-Field	15	65	FMC	9	√	√	$150
University	König II	24	60	FMC	n/a	—	—	$75
University	König II	16	65	FMC	n/a	—	—	$75

the eyepiece marketplace

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
University	König II	12	60	FMC	n/a	—	—	$75
University	König II	8	60	FMC	n/a	—	—	$75
University	König II	6.5	65	FMC	n/a	—	—	$75

Wide Angle — Dual 1.25/2-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Tele Vue	Panoptic	22	68	FMC	16	√	√	$270

Wide Angle — 2-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Meade	Super Wide	40	67	FMC	27	√	—	$300
Meade	Super Wide	32	67	FMC	20	√	—	$240
Orion	MegaVista	40	70	FMC	23	√	—	$230
Orion	MegaVista	34	70	FMC	19	√	—	$200
Orion	Erfle	32	65	MC	42	—	—	$100
Parks	Erfle	32	65	MC	n/a	—	—	$150
Takahashi	Erfle	32	62	FMC	n/a	√	—	$195
Tele Vue	Wide-Field	40	65	FMC	24	√	√	$340
Tele Vue	Panoptic	35	68	FMC	25	√	√	$350
Tele Vue	Wide-Field	32	65	FMC	19	√	√	$270
University	König II 7/70	40	70	FMC	23	√	—	$215
University	König II	40	60	FMC	n/a	—	—	$120
University	König II	32	60	FMC	n/a	—	—	$120
VernonScope	König	32	60	C	19	—	—	$185
Vixen	Lanthanum LV	30	60	FMC	20	√	√	$160

Extra Wide Angle — 1.25-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Meade	Ultra Wide	6.7	84	FMC	11	√	√	$188
Meade	Ultra Wide	4.7	84	FMC	7	√	√	$155
Tele Vue	Nagler	7	82	FMC	10	√	√	$200
Tele Vue	Nagler	4.8	82	FMC	6	√	√	$160
University	Wide Scan	20	82	MC	n/a	√	—	$140
University	Wide Scan	16	82	MC	17	√	—	$130
University	Wide Scan	13	84	MC	n/a	√	—	$110
University	Wide Scan	10	84	MC	7	√	—	$100
University	Wide Scan	6	82	MC	6	√	—	$95

Extra Wide Angle — Dual 1.25/2-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Meade	Ultra Wide	14	84	FMC	23	√	—	$270
Meade	Ultra Wide	8.8	84	FMC	16	√	√	$230
Tele Vue	Nagler II	16	82	FMC	10	√	√	$300
Tele Vue	Nagler	13	82	FMC	18	√	—	$270
Tele Vue	Nagler II	12	82	FMC	11	√	√	$280
Tele Vue	Nagler	9	82	FMC	12	√	√	$240

Extra Wide Angle — 2-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Tele Vue	Nagler II	20	82	FMC	12	√	—	$380
University	Wide Scan	32	84	MC	20	√	—	$215

Ultra Low Power — 2-inch Barrel

Brand	Series	Focal length	Apparent FOV (°)	Coatings	Eye relief (mm)	Eye cups?	Parfocal?	Retail
Celestron	Ultima	80	34	FMC	50	√	—	$250
Celestron	Ultima	60	45	FMC	39	√	—	$250
Celestron	Ultima	45	50	FMC	32	√	—	$210
Clavé	Plössl	75	35	FMC	n/a	—	√	$375
Clavé	Plössl	65	40	FMC	n/a	—	√	$375
Clavé	Plössl	55	45	FMC	n/a	—	√	$375
Clavé	Plössl	45	50	FMC	n/a	—	√	$375
Clavé	Plössl	40	50	FMC	n/a	—	√	$375
Clavé	Plössl	35	50	FMC	n/a	—	√	$375
Clavé	Plössl	30	50	FMC	n/a	—	√	$375
Meade	Super Plössl	56	52	FMC	47	√	—	$230
Orion	Plössl	50	50	MC	20	—	—	$90
Parks	Plössl	50	51	MC	n/a	—	—	$150
Takahashi	LE 50 ER	50	50	FMC	n/a	√	—	$350
Tele Vue	Plössl	55	50	FMC	38	√	—	$240
University	Plössl	55	50	FMC	n/a	—	—	$120
VernonScope	Brandon	48	50	C	38	√	√	$295

NOTES:
All technical specifications are as supplied by the manufacturer. An "n/a" indicates data not available.

Series. The generic optical design or trade name for the model of eyepiece.

Focal length. The focal length of the eyepiece, measured in millimeters — the smaller the number the higher the magnification the eyepiece will provide on any telescope.

Apparent FOV. Apparent field of view of the eyepiece in degrees. To find the actual field of view on your telescope, divide the apparent field by the magnification that eyepiece produces on your telescope.

Coatings. C = single-layer magnesium fluoride coatings, MC = multicoatings on some air-to-glass surfaces, FMC = all air-to-glass surfaces fully multicoated

Eye relief. The distance your eye needs to be from the top lens of the eyepiece in order to see the entire field, measured in millimeters.

Eye cups. A √ indicates the eyepiece comes with some style of rubber eyecup.

Parfocal. A √ indicates the eyepiece reaches focus at close to the same point as other models in the same series.

Price. Prices are typical retail prices at major dealers as of early 1993. All prices are subject to change and may vary from dealer to dealer.

eyepiece designs at a glance

Design	Number of Elements	Apparent FOV (°)	Best for	Comments
STANDARD FIELD				
Kellner	3	35° to 45°	General observing	An economical design suitable for upgrading low-cost telescopes. Works best on f/8 and slower telescopes. Meade's Modified Achromat design is similar.
RKE	3	45°	General observing	Edmund Scientific's trade name for a good economical design with a wider field than many Kellners have.
Orthoscopic	4	40° to 45°	Planets and general observing	Better correction of aberrations than Kellners. Slightly longer eye relief than true Plössls. In premium models, a first-class eyepiece for planet viewing.
Plössl	4	45° to 50°	Planets and general observing	Slightly wider field than most Orthoscopics. A superb eyepiece for the planets. Includes the Clavé and Tele Vue series. VernonScope Brandons are similar.
Modified Plössl	5	50° to 52°	Planets and general observing	A class that includes the Celestron Ultimas, Meade Super Plössls, Orion Ultrascopics, and several other series called Plössls. Superb for all uses.
Lanthanum LV	5 to 8	45° to 50°	Planets and general observing	Vixen's trade name for a series that features 20mm eye relief in all models. High-power models have built-in Barlow lens. Distributed by Celestron.
WIDE-ANGLE				
König, König II	3 to 4	60° to 70°	Deep-sky and lunar	A good economical wide-angle design. Available from University Optics.
Erfle	4 to 6	60° to 70°	Deep-sky	A low-cost design now largely replaced by newer wide-angle models. Exhibits some ghost images and edge aberrations.
Wide-Field, Super Wide, MegaVista	6 to 7	65° to 70°	Deep-sky and lunar	New wide-angle designs that feature minimal ghost images but exhibit some edge aberrations especially on fast f/4 to f/6 telescopes. Suitable for all uses but best for deep-sky viewing.
Panoptic	6	68°	Deep-sky and lunar	Tele Vue's trade name for a design that features good eye relief, high contrast, and minimal edge aberrations even on fast telescopes. Premium prices.
EXTRA-WIDE-ANGLE				
Nagler, Nagler II, Ultra Wide	7 to 8	82° to 84°	Deep-sky, lunar, and planets	All have extremely wide fields with good eye relief and minimal edge aberrations and ghosting. Excellent for use on fast f/4 to f/6 telescopes but suitable for any telescope and object. Premium prices.

edge-to-edge even when used on fast telescopes.

For example, Tele Vue's 6-element **Panoptic** models provide a 68° field with ghost images completely gone, generous eye relief, and only a trace of astigmatism even at the edge. Even more remarkable are the new generation of extra-wide-angle eyepieces. The most popular are the **Ultra Wide Angle** models from Meade and **Nagler** and **Nagler II** series made by Tele Vue. All provide pinpoint stars virtually right to the edge of an amazing 82° to 84° field. All work well on f/4 to f/6 telescopes and have long, comfortable eye reliefs for their focal lengths.

Other Eyepiece Features

Besides optical design and field of view, you should consider several other factors when selecting eyepieces.

Barrel Diameter. Some entry-level telescopes accept only eyepieces with the smaller 0.965-inch-diameter barrels. However, the majority of telescopes on the market now accept 1.25-inch eyepieces. In this larger barrel size, the selection of eyepieces is much greater and includes many wide-angle and extra-wide-angle models.

If you have an import refractor with a 0.965-inch focuser, you can upgrade to 1.25-inch eyepieces by purchasing a "hybrid" star diagonal. This accessory slips into your scope's small-diameter focuser but accepts the larger 1.25-inch eyepieces.

For eyepieces that combine long focal length (yielding low power) *and* wide field, you need to turn to models with 2-inch-diameter barrels. These require telescopes with giant 2-inch focusers. A few eyepieces have barrels that can fit both 2-inch and 1.25-inch focusers. In the tables, these are indicated as Dual 1.25/2-inch Barrel.

Coatings. Most eyepieces have optics coated with at least a single layer of magnesium fluoride on all air-to-glass surfaces. These coatings (which give the glass a bluish tint) help increase light transmission and reduce the internal reflections that create ghost images. Many eyepieces offer multicoated optics. Good multicoatings, which can look yellow, red, green, deep blue, or purple, offer even better contrast and light transmission and are a necessity on complex 6- to 8-element eyepieces.

Filter Threads. Most eyepieces have barrels that are threaded to accept standard filters. Exceptions are the Clavé Plössls and the Zeiss Jena Orthoscopics — their barrels are not threaded. The VernonScope Brandons are threaded but accept only special VernonScope filters.

Eye Cups. More manufacturers are offering eyepieces with rubber eye cups as standard fittings. These help block stray light. The tables indicate which models offer eye cups.

Parfocal. Parfocal eyepieces are part of a series designed to focus at nearly the same point. When you switch eyepieces you do not need to refocus. The tables indicate which models are parfocalized.

Price. In the tables we have broken out all models retailing for $60 and under and listed them as "Economy Eyepieces." There is a good selection here, but all are standard-field eyepieces. To buy a wide-angle eyepiece, you'll need to budget at least $75 to $100.

Choosing a Core Set

With so many types of eyepieces to pick from, selecting a set that's right for you seems difficult. These recommendations may help you narrow your choice:

0.965-Inch. A good core set for a typical department-store telescope would be a 40mm, a 25mm, a 12mm, and a 9mm or 7mm, either Kellners, Modified Achromats, or Orthoscopics. For recommended models see "Economy Eyepieces — 0.965-inch Barrel" in the tables.

1.25-Inch. A set of four eyepieces with 28 to 24mm, 20 to 15mm, 13 to 10mm, and 9 to 7mm focal lengths will provide magnifications to handle just about all observing situations with most telescopes. If you are on a budget, check the listings under "Economy Eyepieces — 1.25-inch Barrel." You could also restrict your choice to as few as two, a 28 to 24mm low-power and a moderate- to high-power 12 to 9mm, and add others later. All designs will work well, but Orthos and Plössls are better for high-power use.

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BARLOW LENSES double or triple the power of any eyepiece. For example, a 10mm eyepiece with a 2x Barlow gives the same power as a 5mm eyepiece but retains the long, comfortable eye relief of the 10mm eyepiece. Barlows are a good alternative to dedicated high-power eyepieces.

ASTRONOMY: Darla Gawelski

Expanding the Core Set

In 0.965-inch barrel sizes there are no wide-angle eyepieces available. You can choose from some superb standard-field models from Takahashi and Zeiss but at over $100 each, these eyepieces are for the planet-observing aficionado and are likely to be beyond the budget of most owners of entry-level telescopes. But in the 1.25-inch size, you have several choices for expanding your core set.

An Ultra-Low-Power Eyepiece. A 35mm to 40mm Plössl or Modified Plössl will show you as much sky as you can get out of any 1.25-inch-diameter eyepiece. If you enjoy deep-sky observing, an eyepiece in this range is an excellent choice as your first additional eyepiece beyond the core set, with one proviso — avoid any eyepiece that provides too low a power.

At too low a power, the eyepiece puts out a cone of light wider than the diameter of the pupil in your dark-adapted eye. Some of the light coming from the telescope will not make it into your eye. In this situation, with reflector telescopes you see the dark shadow of the secondary mirror floating in the center of the field.

A good rule of thumb for determining the longest focal-length (or lowest power) eyepiece you can use is to take the f/ratio of your telescope and multiply it by 7. For example, on any f/4 telescope, the longest eyepiece you should use is a 7 x 4 = 28mm eyepiece. This rule applies for people whose pupils can open as wide as 7mm when fully dark adapted. When you get past age 30, your eyes lose about 1mm of aperture every 10 years. For people aged 40, 6mm is a more likely figure for their dark-adapted pupils. In this case, a 24mm eyepiece (6 x 4) is a better choice as the lowest power model with an f/4 reflector.

An Ultra-High-Power Eyepiece. You might wish to add a 6mm to 2.5mm eyepiece, provided such an eyepiece does not give you much more than 50x to 60x per inch of aperture with your telescope. For example, if you have a 4-inch telescope with a focal length of only 500mm, a 2.5mm eyepiece will give you 200x, a magnification at the upper limit but usable on nights with superb seeing conditions.

Wide-Angle Eyepieces. For spectacular deep space views, consider replacing the low- and medium-power core set eyepieces with wide-angle models. A good first choice would be purchasing a 24mm to 22mm wide-angle instead of the 28mm to 24mm standard-field model. A second choice would be purchasing a 19mm to 15mm wide angle in place of the 18mm to 15mm standard-field eyepiece.

Extra-Wide-Angle Eyepieces. If your budget will allow it, you could select extra-wide-angle eyepieces in the 14 to 4.8mm range for all your moderate- to high-power eyepieces. All will fit 1.25-inch focusers. Extra-wides are especially recommended for owners of fast f/ratio telescopes or for observers keen on deep-sky observing. However, some amateur astronomers prefer to retain less complex Plössls or premium Orthoscopics for high-power planetary use.

Giant Two-Inch Eyepieces

The next step in expanding your viewing choices is, if possible, to outfit your telescope with a focuser or star diagonal that accepts 2-inch-diameter eyepieces. These jumbo models offer wider fields and lower powers than are possible with restrictive 1.25-inch barrels.

2-Inch Wide-Angle Eyepieces. A 32mm to 40mm eyepiece can provide spectacular wide-field vistas of Milky Way starfields. But watch the low-power limit. These focal lengths aren't recommended for reflectors faster than f/5.

2-Inch Ultra-Low-Power Eyepieces. The tables list a class of 2-inch eyepieces that have focal lengths of 35mm to as long as 80mm. All provide low power but within this class, don't think the longer the eyepiece the more sky you'll see. All models in this class have apparent fields of no more than 50°. In models longer than 55mm, the apparent fields are limited by the size of the barrel and can actually shrink to as little as 35°. A 55mm Plössl will show you as much sky as is physically possible with a 2-inch-barrel eyepiece. But surprisingly, a 40mm wide angle, despite its higher power, will show you nearly as much sky on any telescope. This is because it has a wider apparent field — 65°, versus the 50° field of the 55mm Plössl.

Eyepieces Are Forever

Like a fine diamond, a sparkling new eyepiece is a long-term investment. With care, it will never wear out and can be used on any telescope you will ever own. Eyepieces are available for every budget and observing interest. A core set is all you need to get started, but few backyard astronomers stop there. Chances are you won't either. After all, happiness *is* a new eyepiece. ☐

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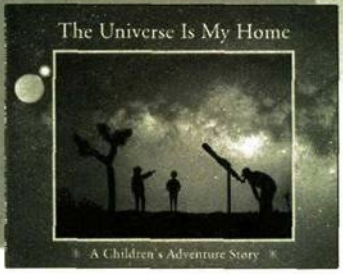

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The constellations of the far north never rise or set, but display their subtle charms through the night all year long.

by Deborah Byrd

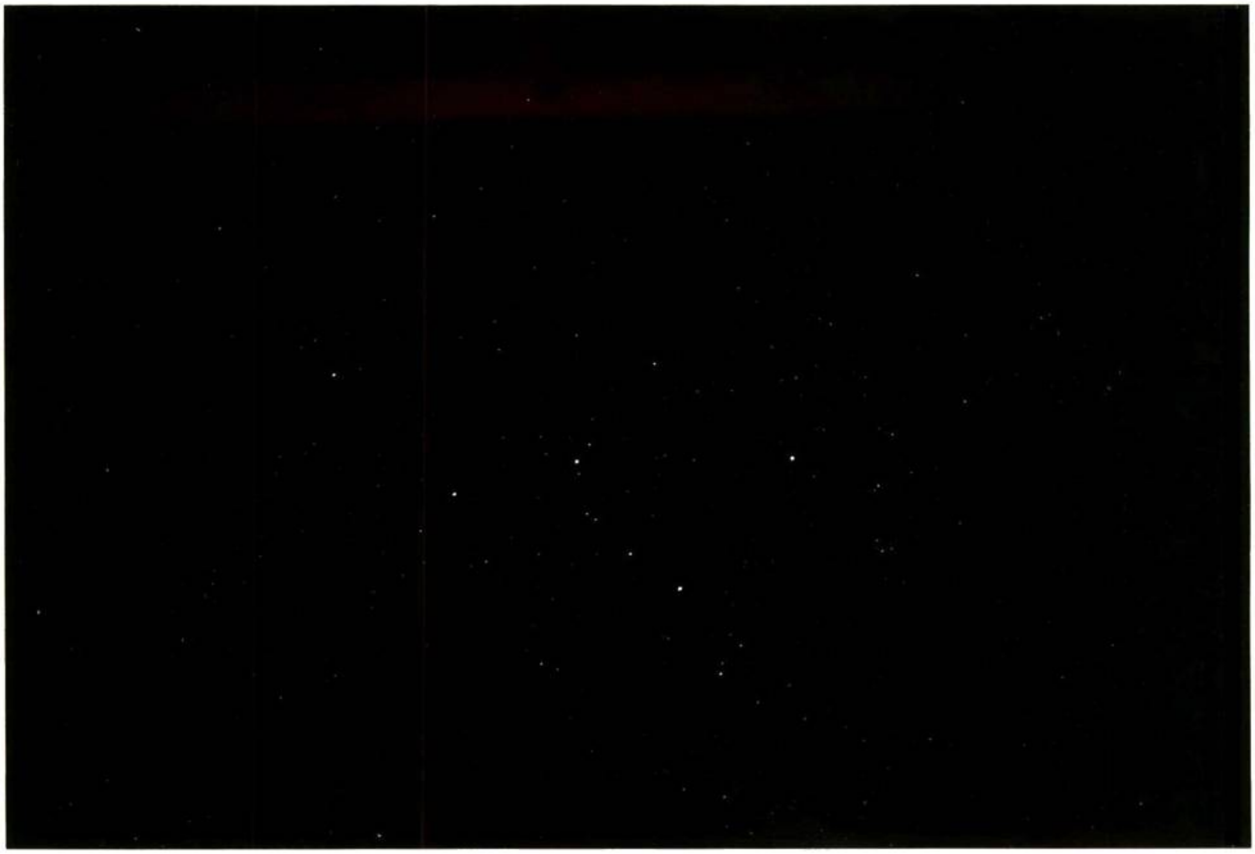
For thousands of years, humans have followed the motions of the Sun, Moon, and stars. On any given day, millions watch as the Sun comes up in the east, arcs slowly across the sky, and sinks in the west. And once darkness falls, the stars repeat the same pattern, as if they ride on some giant celestial wheel.

Most stars do, that is. As seen from the Northern Hemisphere, one region of the heavens contains stars that neither rise nor set. These are the stars that belong to the circumpolar constellations, which remain above the horizon at every hour of the day and night and during every season. These constellations wheel in a counterclockwise circle around the hub of the northern sky, the north celestial pole.

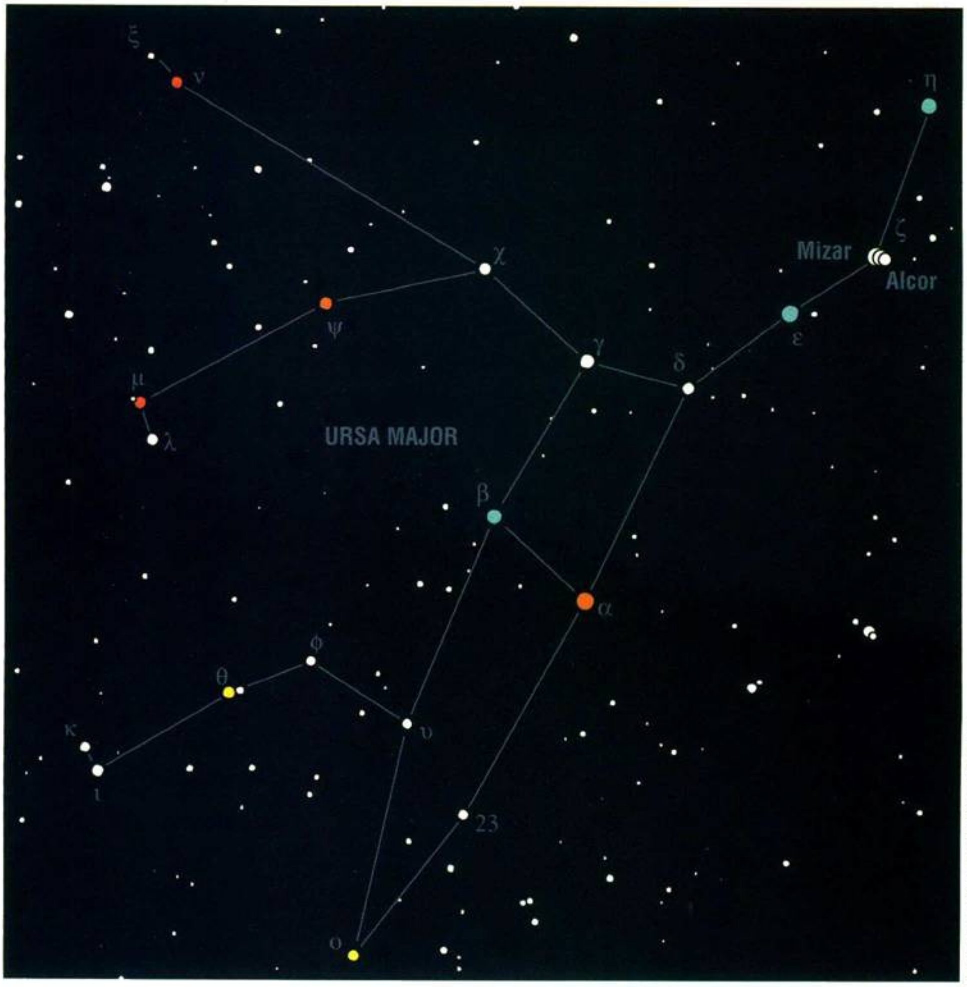
If the sky were a dome instead of fathomless space and if we could extend Earth's northern axis until it reached that dome, it would touch the sky at the north celestial pole. A bright star lies less than a degree from this pole. We call this star Polaris, which is short for *Stella Polaris* (Latin for polar star). It lies close enough to the pole that it appears stationary to the naked eye, while all the other stars circle around it.

But Polaris doesn't stay put as you move around the globe. The altitude of this star and hence the identity of your circumpolar stars depend on your latitude. From 30° north latitude, Polaris lies 30° above the northern horizon and any star within 30° of it

CASSIOPEIA THE QUEEN REIGNS over the northern sky, a group of bright stars shaped like a "W" on spring evenings and an "M" on autumn evenings.



L. H. Price



ASTRONOMY: all maps by Steven G. Davis

A GREAT BEAR RIDES HIGH in the north on spring evenings. Ursa Major, which ranks as the third-largest constellation, is most famous for its bright asterism — the seven stars of the Big Dipper.

is circumpolar. From 40° north latitude, Polaris is 40° high and stars within 40° of it are circumpolar, and so on. (This is what makes Polaris so useful to navigators — measure its altitude above the horizon and you know your latitude.) In our tour of the far northern sky, we'll visit constellations that are circumpolar as seen from about 45° north latitude.

Although Polaris rates as one of the most significant and best known stars in the sky, it is not extremely bright. In fact, at about magnitude 2.0, it ranks only 49th brightest. A supergiant star, Polaris is one of a class known to astronomers as Cepheid variables. Such stars change brightness regularly due to a swelling and shrinking of the star itself. In Polaris' case, the brightness changes only slightly with a period of about four days.

Polaris is also designated Alpha Ursae Minoris (UMi) because it's the brightest star in Ursa Minor the Lesser Bear. (In over half the constellations, Alpha designates the brightest star.) Ursa Minor contains the Little Dipper, an asterism famous for its position near the north celestial pole but not for its brightness: It includes only three stars brighter than 4th magnitude. Because it is quite dim, people in light-polluted urban and suburban areas often find it difficult to trace the entire Little Dipper.

The easiest way to spot this stellar pattern is to start with Polaris, which marks the tip of the Little Dipper's handle. On June evenings, the rest of the Dipper's handle arcs toward the zenith, ending in a four-sided bowl. Ursa Minor's other two conspicuous stars form the far end of the Dipper's bowl and lie a bit over 15° from Polaris. (This is roughly equal to the angular distance between the tips of your thumb and pinkie when you hold your outstretched hand at arm's length.)

The more westerly of the two outer stars in the Dipper's bowl is Kochab (Beta UMi). Kochab shines at magnitude 2.1, just slightly fainter than Polaris, and displays a tinge of orange color. The other outer bowl star is Pherkad (Gamma UMi), which at magnitude 3.1 appears 40 percent as bright as Polaris or Kochab.

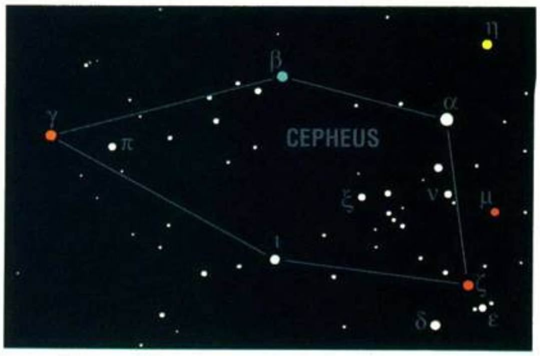
Although seeing the entire Little Dipper may take some effort, you'll have no such problem with its larger sibling. The Big Dipper, in the constellation Ursa Major the Greater Bear, is the dominant feature of the northern sky. Unlike the stars in most asterisms, which are physically unrelated, the Dipper's stars appear close to one another because many of them *are* close together. Five of the seven bright stars in the Dipper belong to a single star cluster, the Ursa Major moving group. The cluster lies about 75 light-years away, making it the nearest known star cluster to Earth.

The four stars in the bowl of the Big Dipper (above) are Dubhe (Alpha [α] Ursae Majoris), Merak (Beta [β] UMa), Phecda (Gamma [γ] UMa), and Megrez (Delta [δ] UMa). A line drawn through Merak and Dubhe and extended northward about five times the distance between the two stars leads to Polaris.

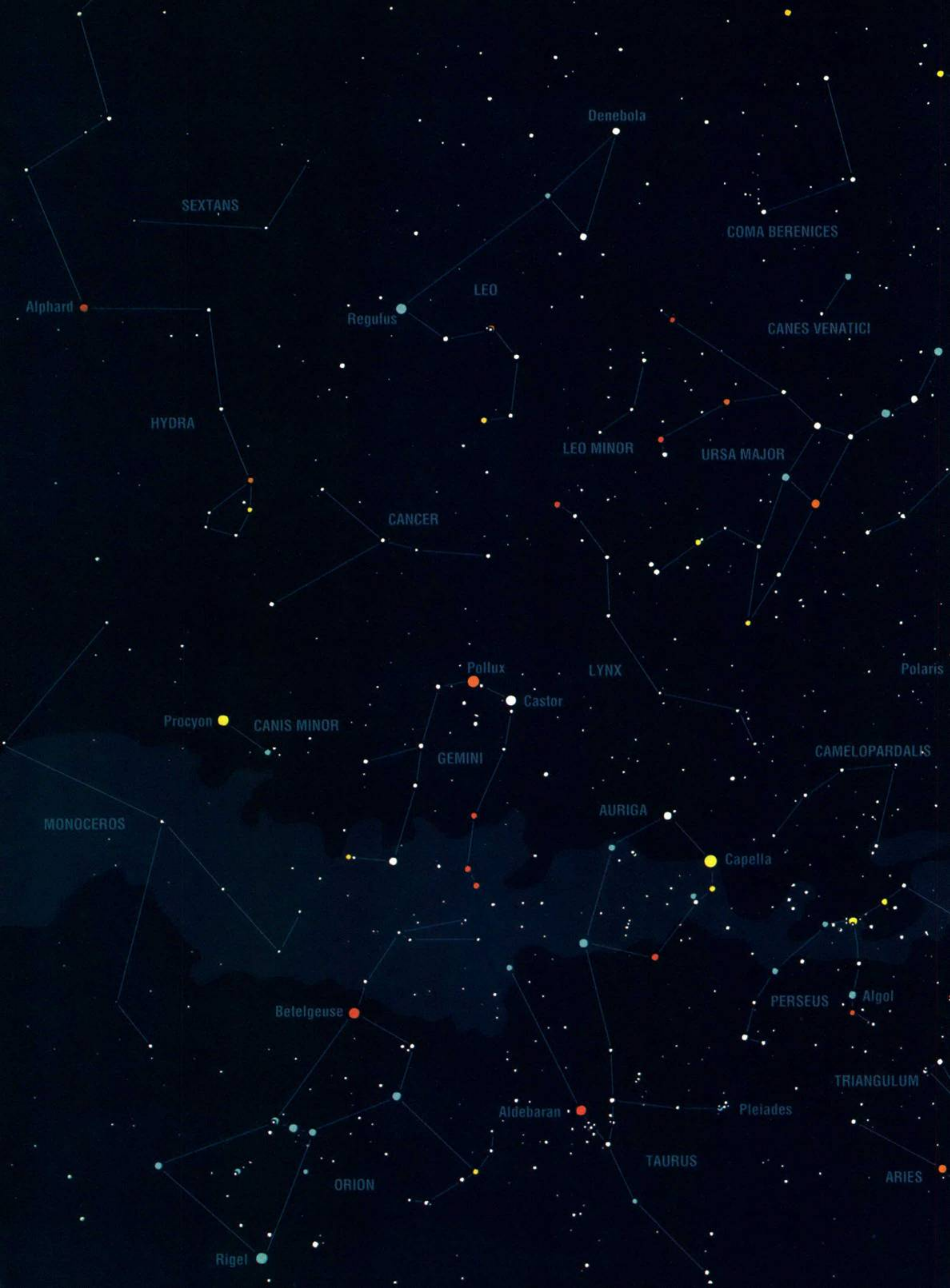
The three stars in the Dipper's handle are Alioth (Epsilon [ε] UMa), Mizar (Zeta [ζ] UMa), and Alkaid (Eta [η] UMa). Mizar — shining at magnitude 2.3 at the bend in the Dipper's handle — consists of two stars, both visible in a small telescope.

Immediately east of Mizar you'll see a 4th-magnitude star called Alcor. Early Arabian stargazers used Mizar and Alcor to test their eyes — if you could see both stars, you had good eyesight. These stars still make for a good test, though most people have little trouble splitting the pair. Mizar and Alcor both belong to the Ursa Major moving group, but they probably don't orbit each other.

CEPHEUS THE KING BOASTS two intriguing stars: Delta (δ) Cephei, the prototype Cepheid variable, and Mu (μ) Cephei, the ruddy "Garnet Star."



In June, the Big Dipper can be found high in the north after sunset, but as night passes it sinks in the northwest. As it descends, it follows the path of two much less conspicuous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Pollux
LYNX
Polaris
Castor
Procyon
CANIS MINOR
CAMELOPARDALIS
GEMINI
MONOCEROS
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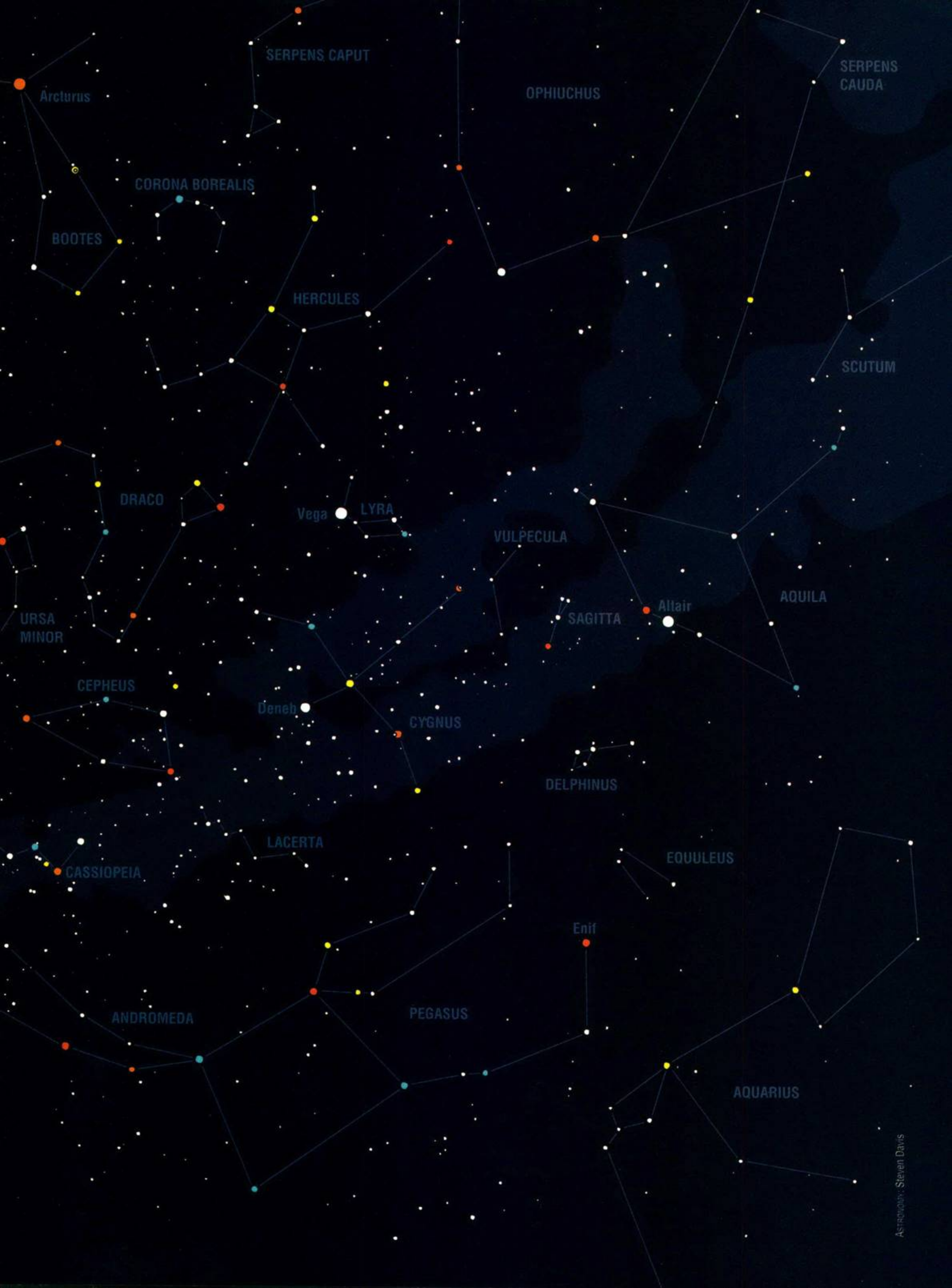
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Vega
LYRA
VULPECULA
AQUILA
URSA MINOR
Altair
SAGITTA
CEPHEUS
Deneb
CYGNUS
DELPHINUS
LACERTA
EQUULEUS
CASSIOPEIA
Enif
ANDROMEDA
PEGASUS
AQUARIUS

ASTRONOMY: Steven Davis

constellations: Lynx the Lynx and Camelopardalis the Giraffe. The name of the latter originated in ancient Rome, where a giraffe was described as having the hump of a camel and the spots of a leopard. Camelopardalis contains no star brighter than 4th magnitude. Lynx is slightly brighter than Camelopardalis but not much easier to trace.

On the other side of the Big Dipper from Camelopardalis and Lynx lies one of the most legendary of all constellations. Draco the Dragon (right) winds around the sky's north pole like a dragon of the ancient myths, guarding its treasure. We're not sure which creature the Greeks named it after, but the Dragon may represent the one slain by Hercules in his Eleventh Labor. In the sky, Draco lies just north of Hercules, who is kneeling with one of his feet on the Dragon's head.

THE NORTHERNMOST CONSTELLATION is Ursa Minor the Lesser Bear. It contains both the Little Dipper and Polaris, the star around which all others appear to rotate.

Daniel J. McGlaun, Jr.

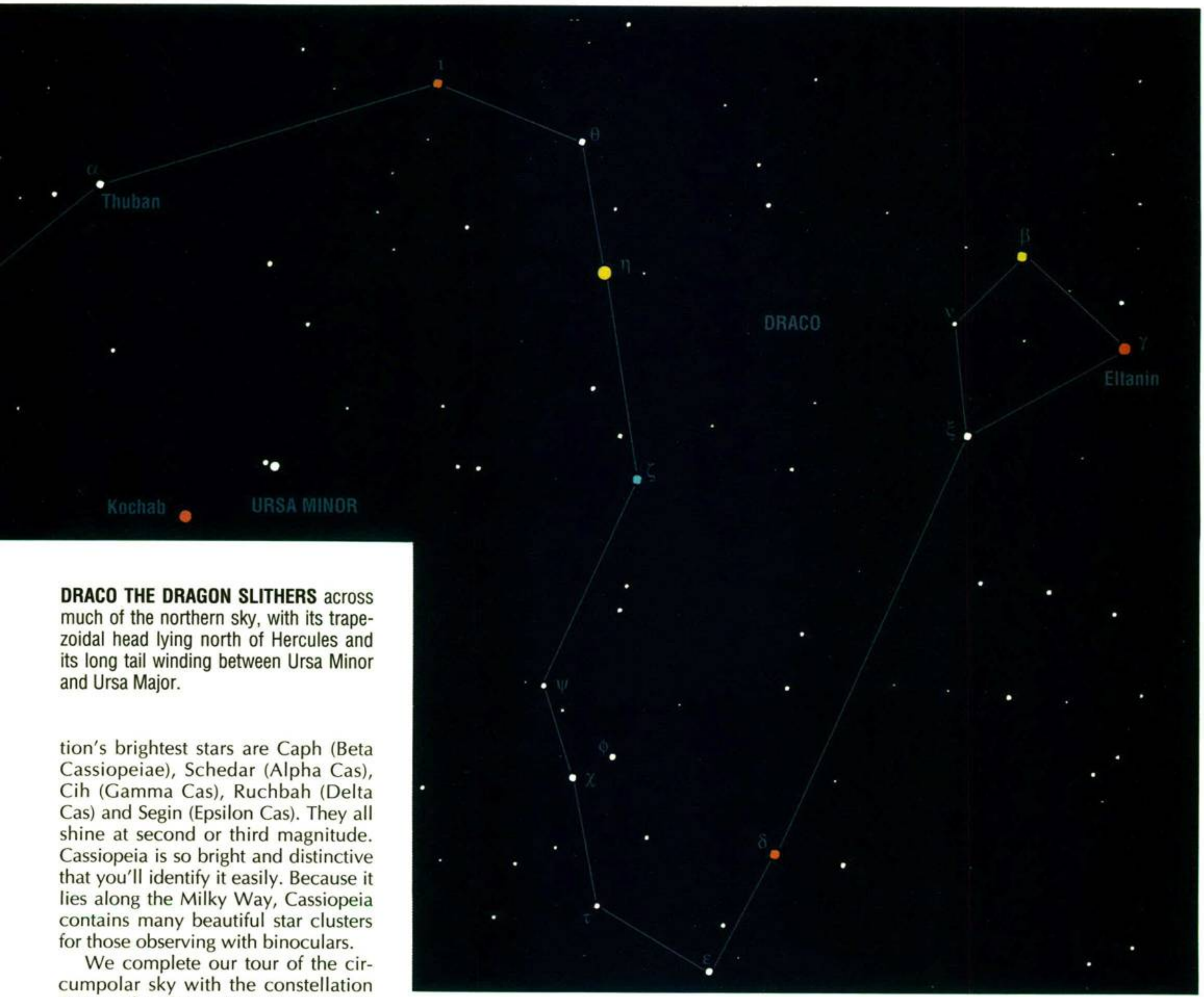
Draco's brightest star is Eltanin (Gamma Draconis), whose name comes from an Arabic phrase meaning "the dragon's head." This star shines at 2nd magnitude just north of Hercules and about 15° northwest of blue-white Vega in the constellation Lyra. The 3rd-magnitude star shining near Eltanin is called Rastaban (Beta Draconis). Rastaban, Eltanin, and two fainter stars represent Draco's head.

Now trace the Dragon from its head to its tail, first moving northeast, then west, then southwest, and finally northwest. In the tail you'll find the star Thuban (Alpha Draconis). Although Thuban is not particularly bright at magnitude 3.7, it is one of the sky's most celebrated stars because it once served as the polar star. You can find Thuban easily by looking roughly halfway between the bowl of the Little Dipper and the star Mizar in Ursa Major.

It's fascinating to gaze at Thuban and contemplate its significance to ancient civilizations. It was the polar star around 3,000 B.C., during the time the Egyptians built the pyramids. In the year 2102, the distance between the current polar star, Polaris, and the north celestial pole will be at its least. The identity of the polar star shifts over the eons because Earth's axis slowly gyrates. It traces out a circle among the northern stars every 26,000 years, in a motion called precession.

Continuing clockwise around the pole from Draco, you'll next encounter a relatively faint constellation with a distinctive shape. Cepheus the King (see page 69) resembles a child's drawing of a house, with a square for the base and a triangle for the roof. Its brightest star, Alderamin (Alpha Cephei), shines at magnitude 2.4. Look also for the first Cepheid variable discovered, Delta Cephei (eponym of this class of variables) and Mu Cephei, a red supergiant star famous for its color. Mu is the reddest naked-eye star in the northern sky, which led German-English astronomer William Herschel to call it the Garnet Star. Its color is noticeable to the naked eye and striking in binoculars.

After Cepheus, the next stellar grouping heading clockwise around the pole is the prominent circumpolar constellation Cassiopeia the Queen. It's located directly opposite Polaris from the Big Dipper. On June evenings, for example, as the Dipper descends in the northwest, Cassiopeia ascends in the northeast. This constellation has the shape of the letter M or W, depending on the season: On spring evenings it appears as a W below Polaris, on autumn evenings as an M above Polaris. The constella-



DRACO THE DRAGON SLITHERS across much of the northern sky, with its trapezoidal head lying north of Hercules and its long tail winding between Ursa Minor and Ursa Major.

tion's brightest stars are Caph (Beta Cassiopeiae), Schedar (Alpha Cas), Cih (Gamma Cas), Ruchbah (Delta Cas) and Segin (Epsilon Cas). They all shine at second or third magnitude. Cassiopeia is so bright and distinctive that you'll identify it easily. Because it lies along the Milky Way, Cassiopeia contains many beautiful star clusters for those observing with binoculars.

We complete our tour of the circumpolar sky with the constellation Perseus the Hero, which lies between Cassiopeia and Camelopardalis. In June it appears near the horizon (below it as seen from the southern states) until the wee hours. Its brightest star is Mirfak (Alpha Persei), also sometimes called Algenib, which shines at magnitude 1.8.

Astrologers once considered Algol (Beta Persei) to be the most dangerous, violent, and unlucky star in the heavens. It has been called the Ghoul Star, because to ancient Arabic astronomers it represented the head of the Gorgon Medusa, who had snakes instead of hair. Algol is one of the sky's best known eclipsing binary stars. It consists of two stars orbiting in our line of sight. Algol normally appears about as bright as Mirfak, but every 2 days, 20 hours, and 49 minutes, it dims noticeably and stays dimmer for about 10 hours. This happens because the fainter of the two stars passes in front of the brighter one, blocking much of its light from our view and causing the system to fade.

Naked-eye observers can detect a patch of mist one-third of the way between Perseus and Cassiopeia, which binoculars reveal as a double star cluster. This is the famous Double Cluster, also known as h and Chi Persei. Unless you are at a very northerly latitude, this cluster is best seen in the hours before dawn in June or on autumn evenings.

In modern culture, the circumpolar constellations are perceived to be like an ever-turning wheel or like hands moving backward on a malfunctioning clock. In ancient China, the motion in this part of the heavens had deeper significance, linked to key mysteries of existence. For the Chinese the circumpolar constellations represented the axis of the universe or the wheel of life.

The motion of the circumpolar constellations is integral to their charm. They follow each other in an endless circle around the sky's north pole, ascending in the northeast, reaching their highest point in the north, and descending in the northwest. On some clear evening, take a blanket outside and watch them as Earth spins and the night sky turns. ☐

Deborah Byrd writes ASTRONOMY'S *monthly sky column "Eye on the Sky." Her last feature article was "Exploring the Spring Sky" in the March 1993 issue.*

THE DIGITAL UNIVERSE

Today's CCD astrophotographers are creating impressive galleries of electronic celestial images.

by Alan Dyer

THE ELUSIVE HORSEHEAD NEBULA is an easy target for the sensitive eyes of a CCD camera. Tim Hunter used a Photometrics Star-1 camera and a 25-inch f/5 telescope.

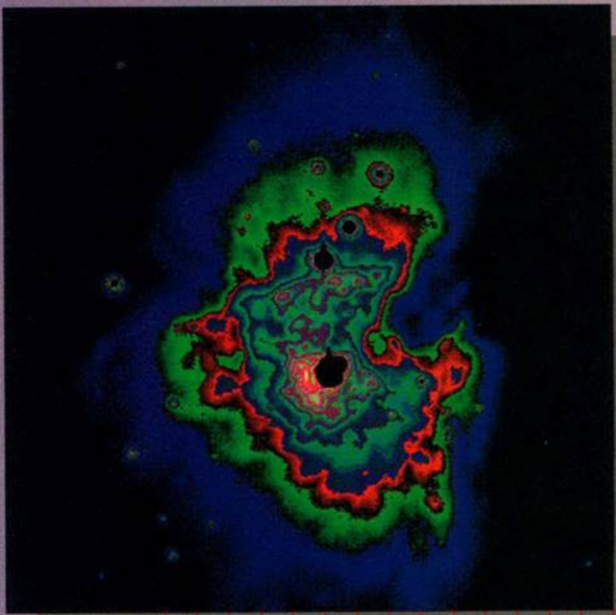
Talk to any of the growing number of amateur astrophotographers who have turned to charge-coupled-device, or CCD, cameras and you'll get the same enthusiastic response — "I've never had so much fun doing astrophotography!"

When you listen to CCD addicts at meetings and star parties, their enthusiasm can be overwhelming. Some amateurs who have been taking pictures of the night sky for decades — people who have seen it all, photographed it all, and used all the standard techniques with conventional film — have been re-energized by the power of CCD cameras.

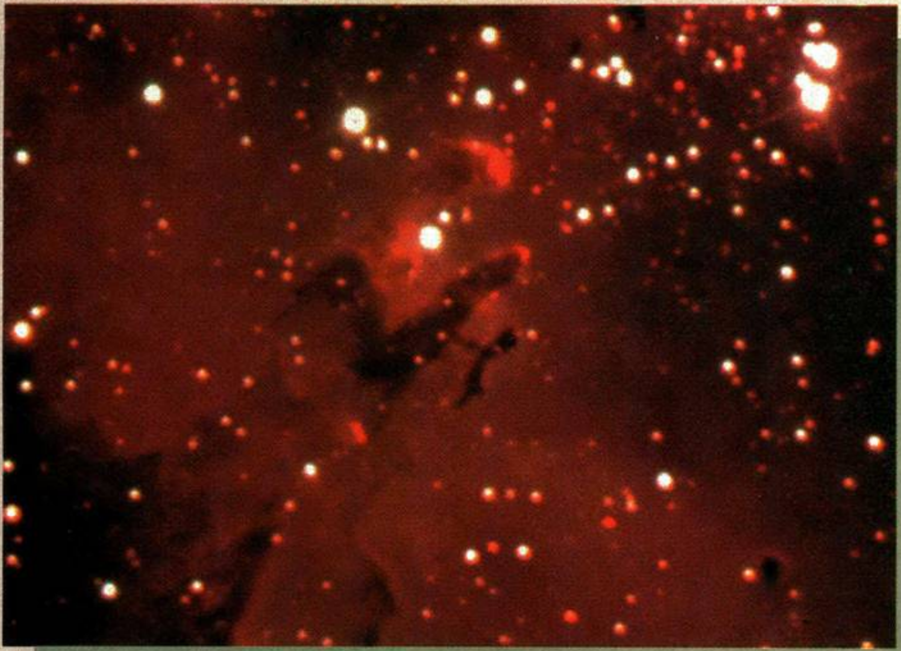
The new digital cameras can record faint deep-sky objects in exposure times a fraction of what most films require. The images are stored electronically and can then be massaged and manipulated on a computer with the same ease as moving words around in a text file. If you've ever worked on a computer, you've discovered how easily hours can slip by as you write, cut, paste, edit, draw, sort, and calculate. Working with images you've captured with your own telescope is even more intoxicating.

The new cameras appeal not only to veteran amateur astronomers. People new to the hobby are also finding CCD technology an attractive alternative to the long exposures, tedious guiding, and hours of darkroom work often required for the best results with film. Many of the new generation of amateur astronomers grew up with computers; for them computers are familiar tools which they now find they can apply to their new interest of amateur astronomy.

But technology aside, both newcomers and veterans probably find one characteristic of CCD cameras most appealing: the instant gratification the cameras provide. Take an image and moments later it appears on the computer monitor. If you don't like it, erase it and take another. Combine the immediate feedback with the new technology's other attractions and it's easy to see why CCD cameras are being called the future of amateur astrophotography.

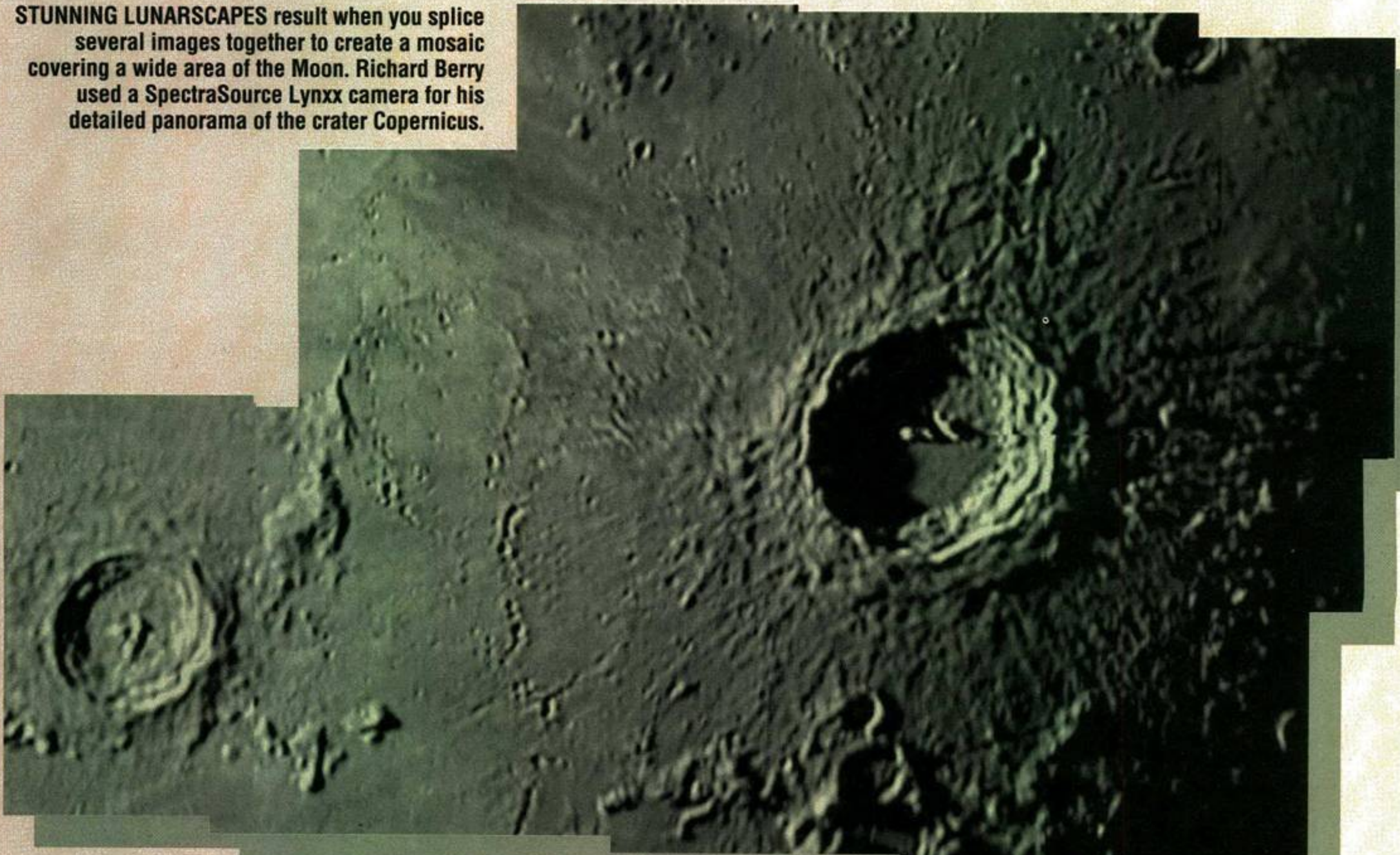


A PALETTE OF WILD COLORS turns an image of the Orion Nebula into a surrealistic abstract (above). George Fowler captured the original monochrome image (left) with a Star-1 camera and added the false-color enhancement during computer processing.



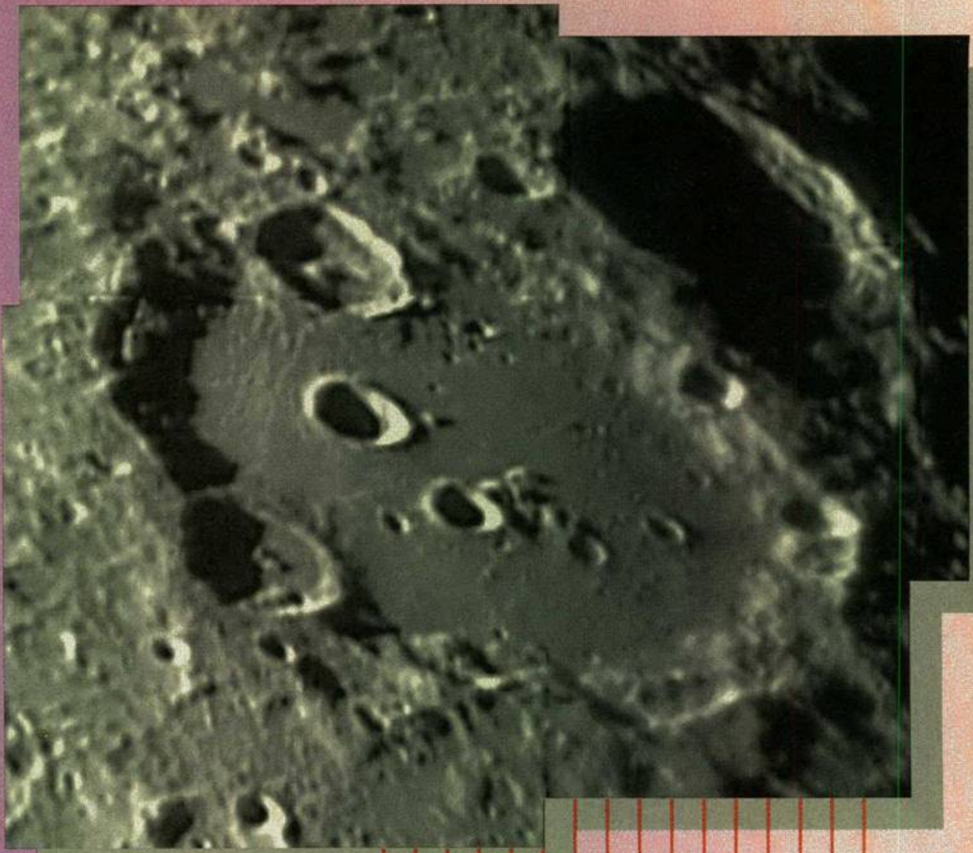
TRUE COLOR IMAGES are possible but require taking three exposures — one each through red, green, and blue filters — and then merging them with a computer. Jack Newton's CCD color portrait of the Eagle Nebula, M16, is such a tricolor composite.

STUNNING LUNARSCAPES result when you splice several images together to create a mosaic covering a wide area of the Moon. Richard Berry used a SpectraSource Lynxx camera for his detailed panorama of the crater Copernicus.

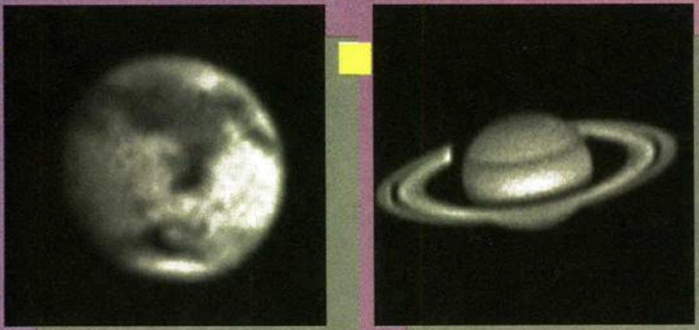


CCD cameras aren't just for faint deep-sky targets. In fact, many of the finest amateur CCD images are shots of the Moon and planets. For best results, the trick is to magnify the image enough so that the square "grain" of a CCD's pixels is smaller than the resolving power of the telescope.

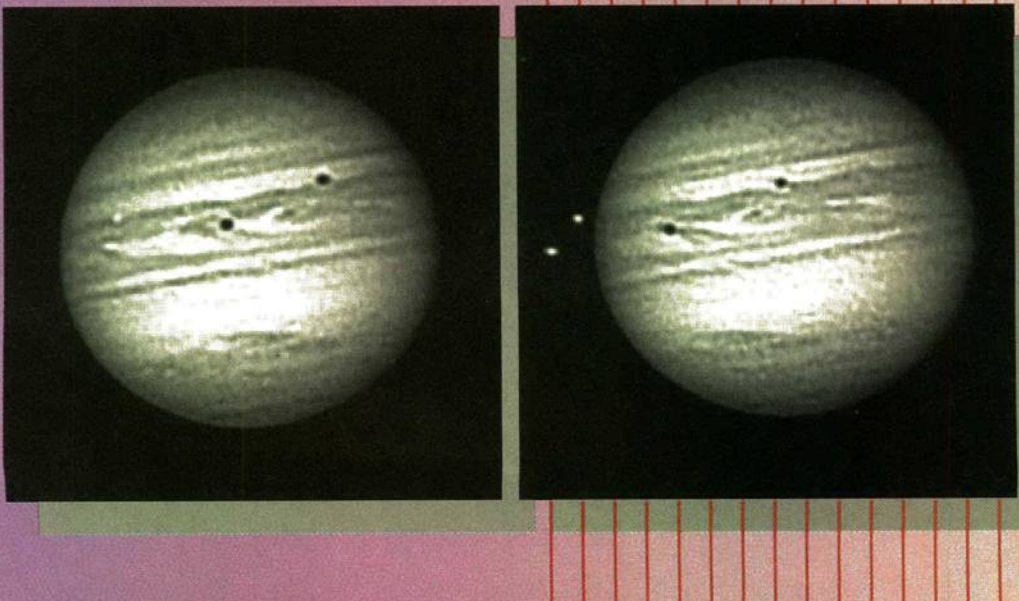
For example, Jupiter's 40-arcsecond-wide disk should cover at least 80 pixels (160 is better). Each pixel then covers no more than 0.5 arcsecond, the typical practical limit of resolution.



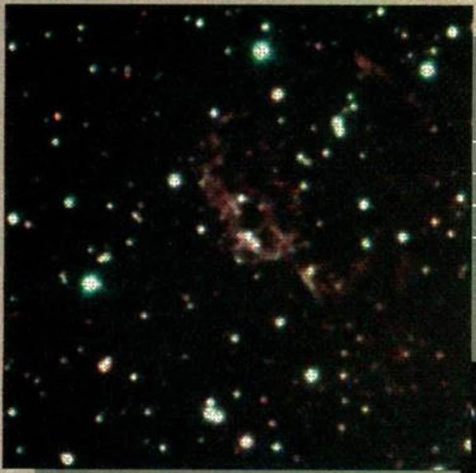
CRATERS ONLY A FEW MILES ACROSS pockmark the floor of Clavius in this stunning lunar mosaic by Richard Berry, proof that CCD cameras are not just for deep-sky objects.

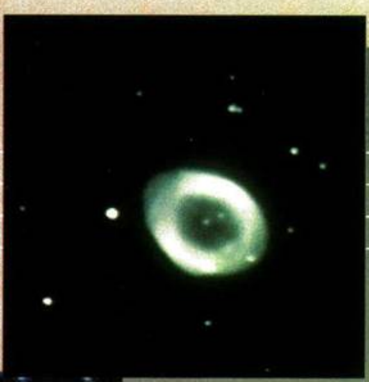


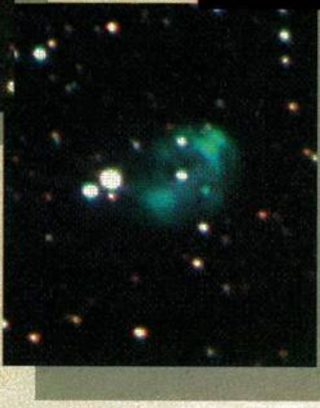
MORE AND MORE CCD FANS are turning their cameras on the planets. Gregory Terrance used a SpectraSource Lynxx camera and a 16-inch f/5 telescope operating at about f/30 to record Mars in late 1992 (far left) and Saturn (left) in mid-1992.



DANCING DOUBLE MOONS were recorded by Gregory Terrance in a pair of CCD images of Jupiter. At right, the moons appear as two white specks on the planet's cloudtops and their shadows as two dark spots. At far right, the moons have moved off the disk while their shadows remain in transit.



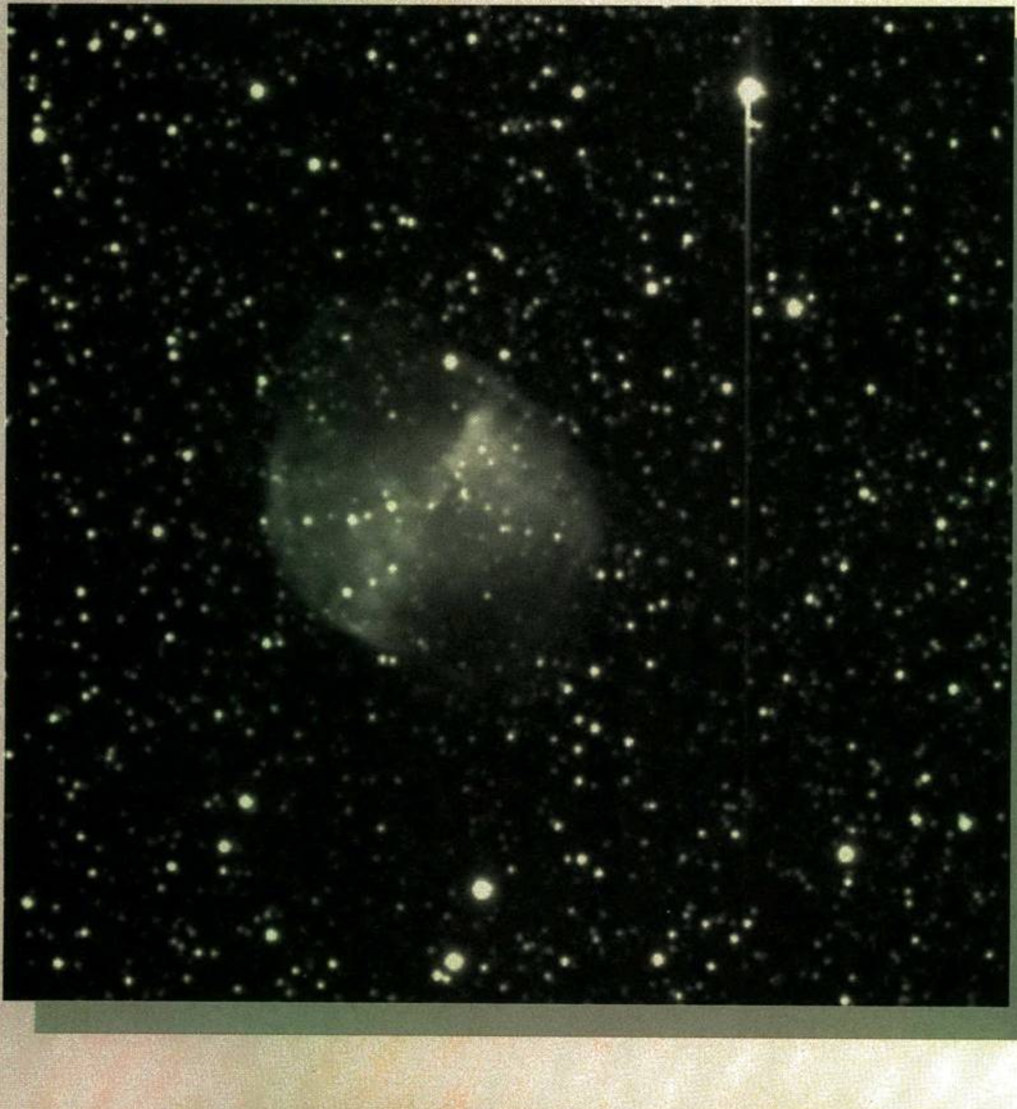




THE ULTRA-FAINT REMNANTS (far left) of a supernova in Cassiopeia called Cas A were captured by Paul Boltwood using a custom-made camera. For his 3-minute exposure of the well-known Ring Nebula (M57, left), Ronald Kohl used a Star-1 camera. The strikingly blue planetary nebula called NGC 7008 (below left) shows up in Jack Newton's tri-color image taken with an SBIG ST-6 camera.

The small size of the light-sensitive chip in most CCD cameras means that the cameras can see only a small section of sky. For example, when connected to an 8-inch f/6.3 Schmidt-Cassegrain, the popular ST-6 model camera provides a field about 24 arcminutes across, slightly less than the diameter of the Moon.

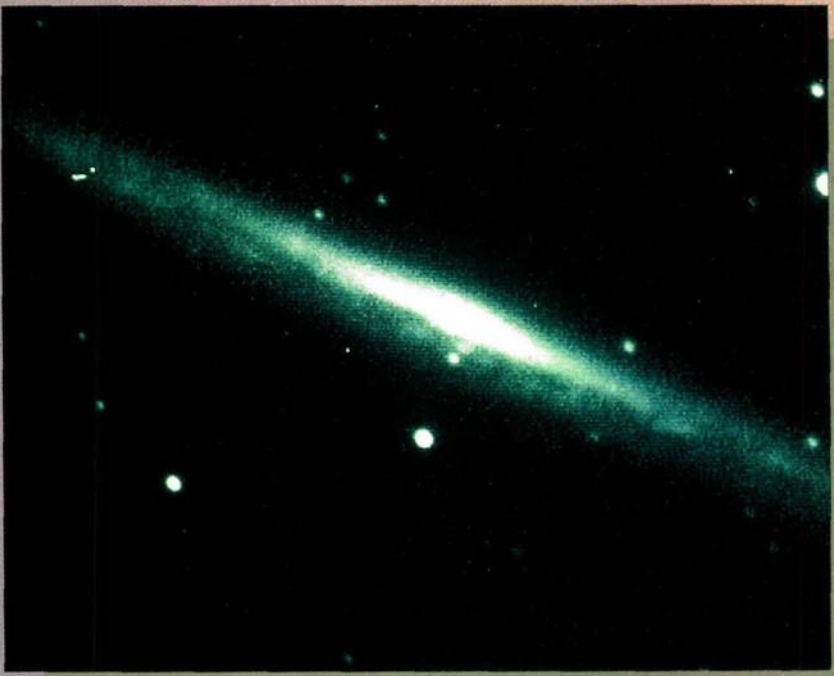
For this reason, the deep-sky targets best suited for telescopic CCD imaging are small objects such as planetary nebulae and galaxies.



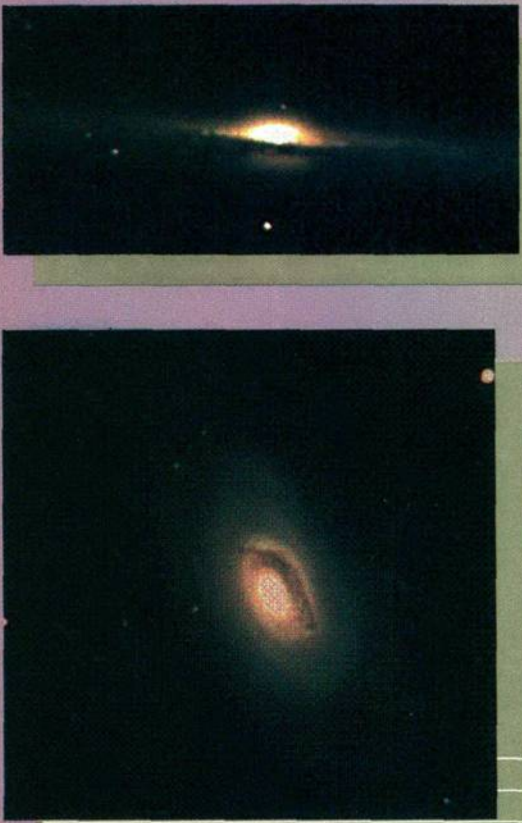
THE GHOSTLY DUMBBELL floats in a field of stars in Paul Boltwood's portrait of the planetary nebula M27. Boltwood often uses his 7-inch f/9 refractor at f/22. The boost in focal length increases exposure time but also increases image size and detail.

Galaxies are favorite targets for digital astrophotographers. Most galaxies are 2 to 20 arcminutes across, dimensions well-suited to the fields of view of CCD cameras. Galaxies also contain details such as dust lanes, spiral arms, and faint outer halos that show up well in frames with adequate exposure (2 to 10 minutes).

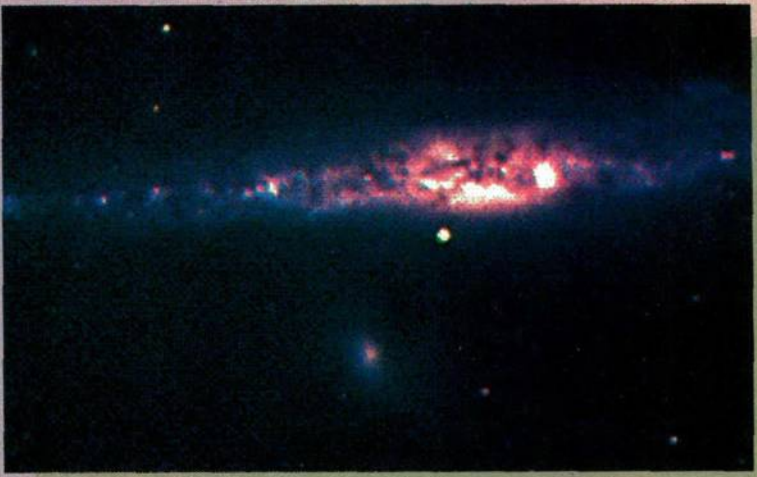
Compared with the 30- to 90-minute exposures required by conventional films, the short exposures of CCD cameras make guiding and polar alignment much less critical and a typical night of imaging much more productive.



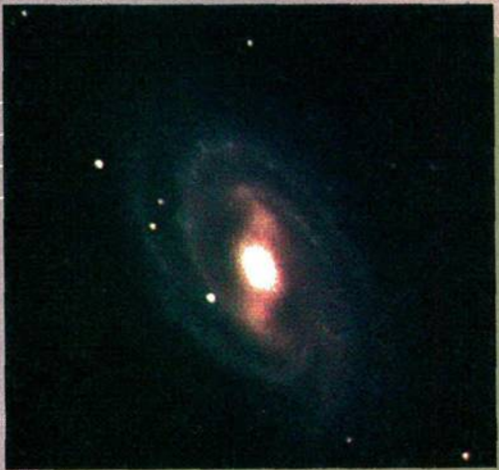
EDGE-ON GALAXIES are striking objects for any type of camera. Ronald Kohl used a 2-minute exposure and a Star-I camera attached to a 20-inch Cassegrain telescope for this portrait of NGC 5907 in Draco.



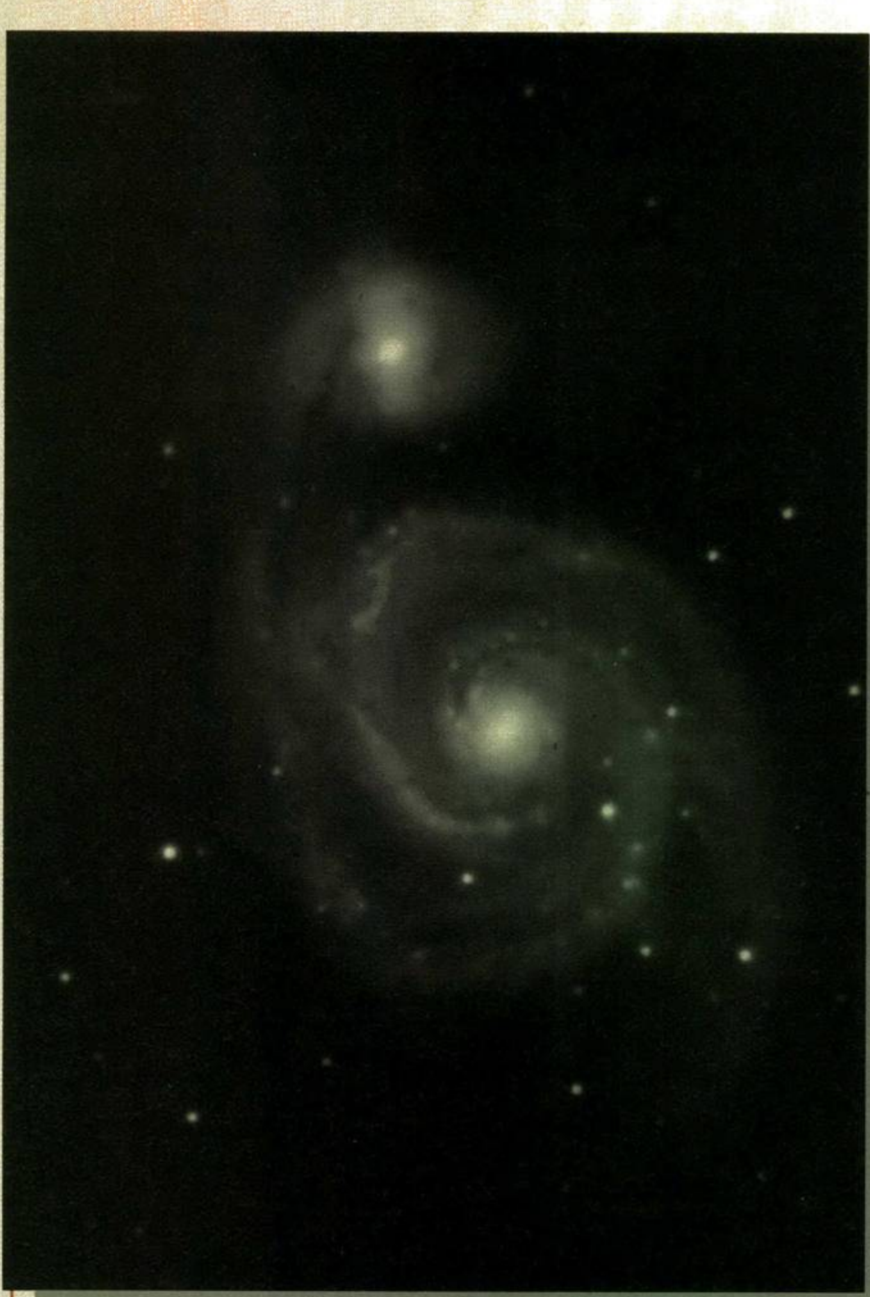
DUST LANES AND DARK EYES *show up in* Jack Newton's CCD images of NGC 4565 (top) and M64, the Blackeye Galaxy (bottom). Newton often shoots a trio of images of each object through different filters to make color images such as these.



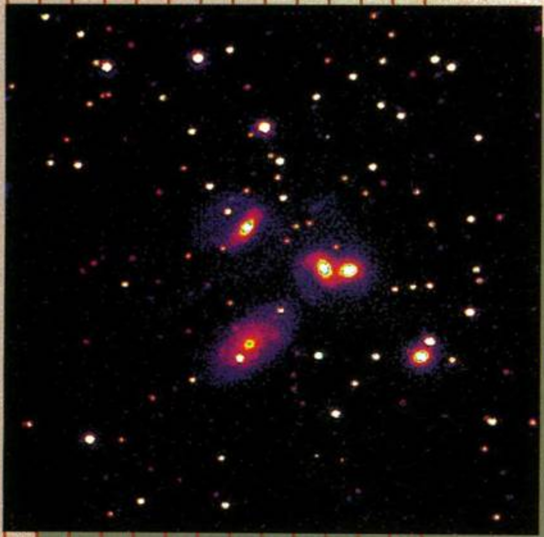
A TANGLE OF DUST CLOUDS is the hallmark of NGC 4631, a large edge-on galaxy in Canes Venatici. Nearby is its companion galaxy, a small elliptical called NGC 4627. Newton used three 10-minute exposures with an ST-6 camera and a 25-inch f/4 reflector.



SPIRAL ARMS unwind off a bright central bar in Newton's digital image of M109, a bright galaxy near Gamma Ursae Majoris, *one of the stars in the* bowl of the Big Dipper.



THE WONDROUS WHIRLPOOL makes a beautiful subject for the new generation of CCD cameras. Tim Hunter captured and digitized the spiral galaxy's image with a Star-1 camera and a 25-inch telescope.



IT TOOK ONLY 5 MINUTES for Ronald Kohl to record the faint light coming from this group of 15th-magnitude galaxies in Pegasus called Stephan's Quintet, a tribute to the recording power of the CCD cameras now available to astrophotographers.

CCD cameras are very sensitive. They can record even a small trickle of photons, making them ideal for going after faint deep-sky targets. These include the outlying structures around nebulae and galaxies and dim objects such as distant clusters of galaxies.

In all, the CCD camera is proving to be a powerful new tool for amateur astronomers, one that is revolutionizing the craft of astrophotography. □

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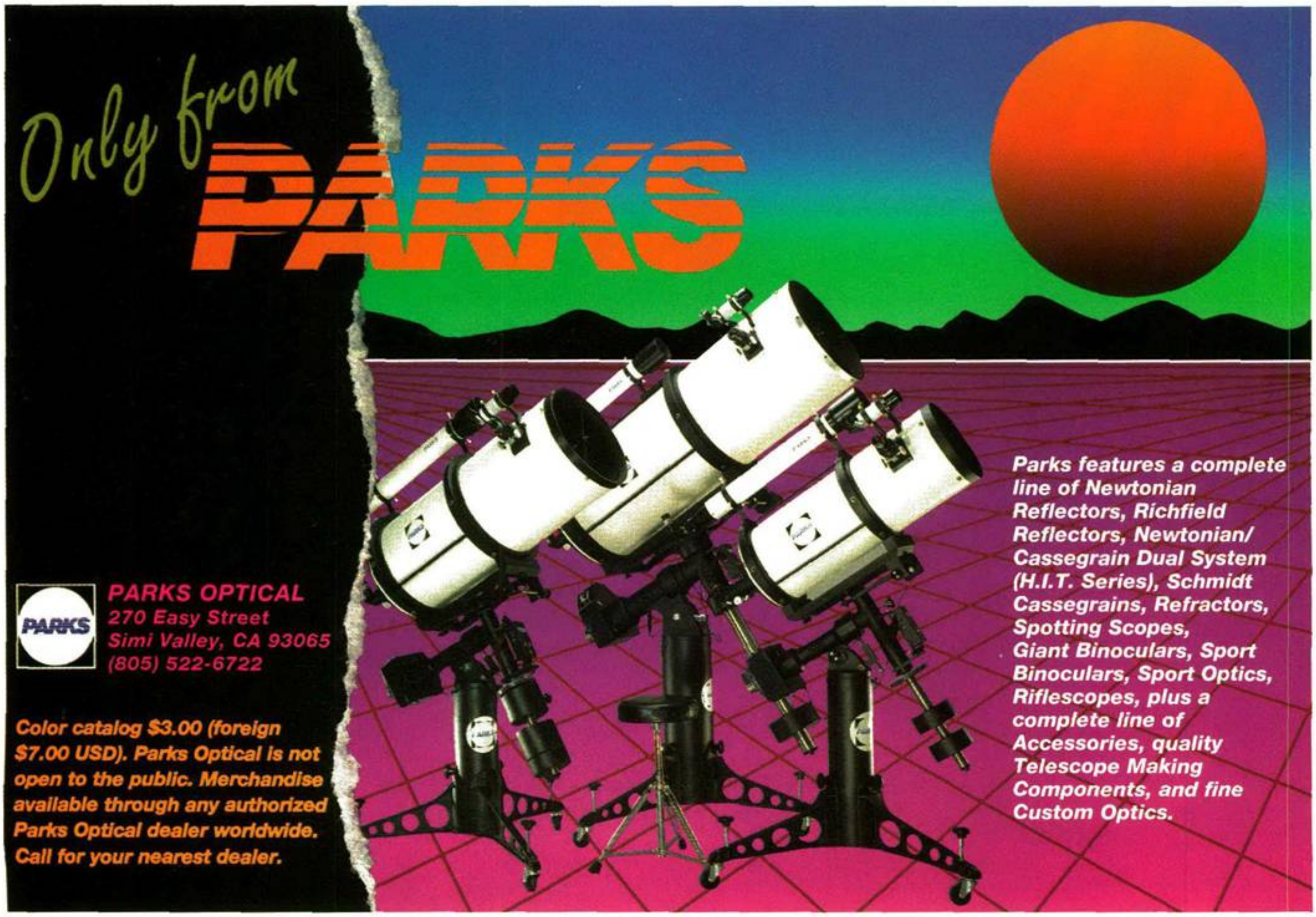

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ASTRO SHOTS FROM THE CITY

Many beginning astrophotographers write ASTRONOMY and say they are intimidated by city-bound astrophotography. "You really need a dark, California sky for doing anything that looks reasonably good, right?" ends one recent letter. Yet that isn't true. We regularly receive impressive astrophotos made from suburban or even urban locations.

For example, Paolo Candy shoots astrophotos from the balcony of his home in Viterbo, Italy. He uses an 8-inch SCT at f/6.3 and a wide range of astrophoto accessories. A professor of mathematics and physics at the Military Academy of Viterbo, Candy has been taking pictures from his home for two years now. "I would like to share my photos with your readers and tell them that photography of sky objects is possible with a simple telescope from such a location," he says.

Bright Meteors Observed. We continue to receive many reports of observers seeing very bright meteors. Twelve-year-old Eric Ward of Marietta, Georgia, spotted an "amazing" meteor flashing across Orion on January 30, 1993.

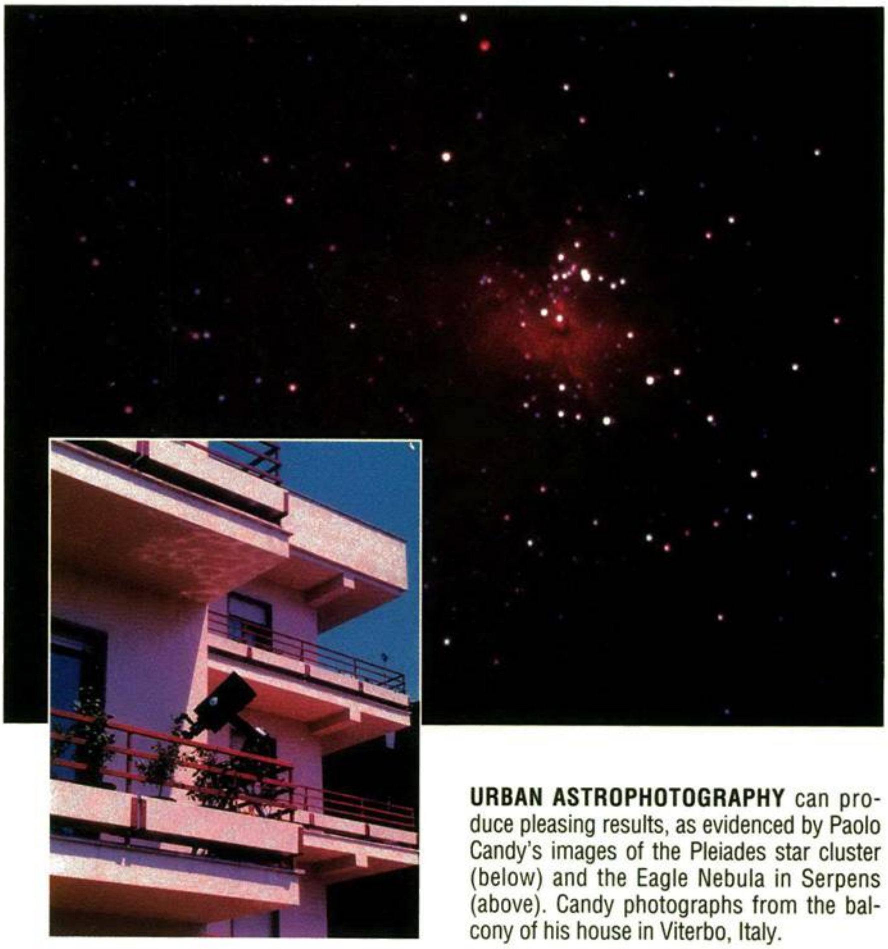
Anne F. Bauman of Garnett, Kansas, recalls seeing a fireball in January 1990, shortly after she entered the hobby. "I was viewing Castor and Pollux," she says, "and as I turned my vision northward I saw a magnificent, glittering, white 'bolt' shooting across the sky, trailing blue, red, orange, and yellow sparkles behind it. As it crossed the sky I heard a hissing sound that abruptly stopped with a memorable sound — SHOOP."

In recent years two meteors graced the sky over William W. Laythe of Sturbridge, Massachusetts. Last November 28/29 a meteor flash was so bright that Laythe at first thought someone was approaching with a flashlight. "The fireball descended from below Ursa Major down to the horizon," he says, "and was a brilliant yellow-white." An earlier bolide in the winter of 1988 flared so brightly that Laythe observed blue and green from his car window while stopped at a suburban traffic light.

Troy Allen Campbell of Torrance, California, spotted a bright fireball on November 29, 1992. "I was taking one last look after a night's observing when a bolide streaked across the sky and produced yellow, orange, and greenish fragments," he says. "I followed the meteor as it sank down over the Palos Verdes Peninsula."

Venus and the Moon. On October 28, 1992, Franz Kufer of Munich, Germany, was adjusting his telescope on the roof-terrace of his hotel in Crete, preparing for a night's observing. Friend Joe Cascal and Kufer noticed that Venus and the Moon were separated by a small distance. Stumbling onto this conjunction was "a spectacular event," says Cascal. "We started observing the pair and found they were moving closer. Pretty soon the two could not be separated by the naked eye, so we kept snapping photos with Franz's camera." Later the photos showed that no occultation occurred from Crete, but the serendipitous nature of the observations created a memorable night for Cascal and Kufer. ☐

ASTRONOMY wants to hear about your observations of the sky. Please send reports, sketches, and photos to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187.

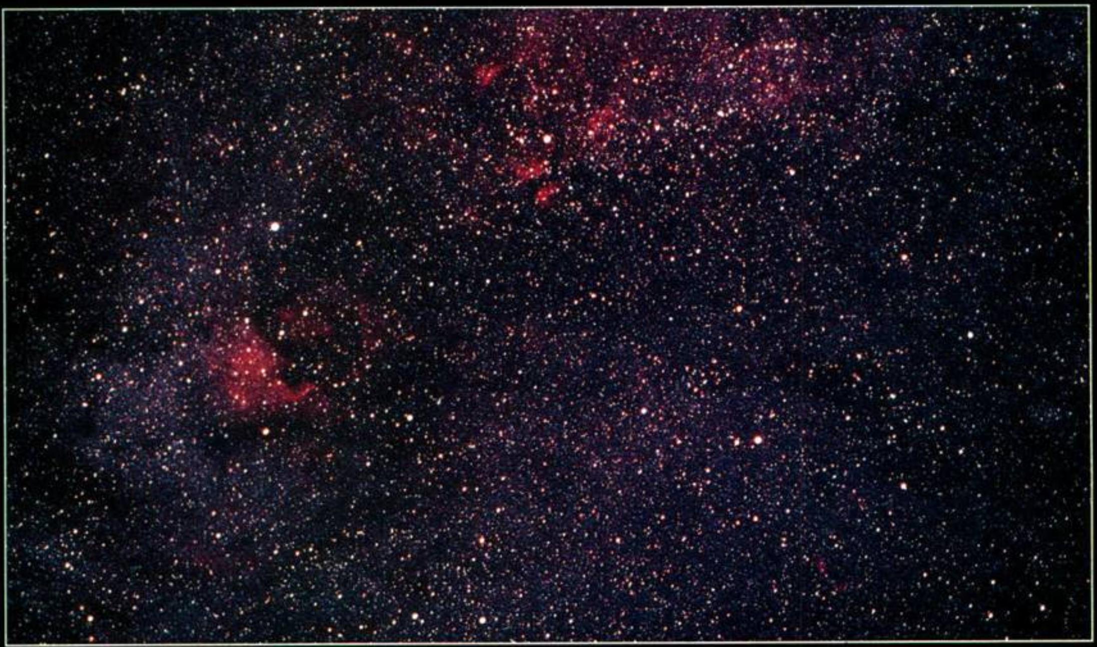


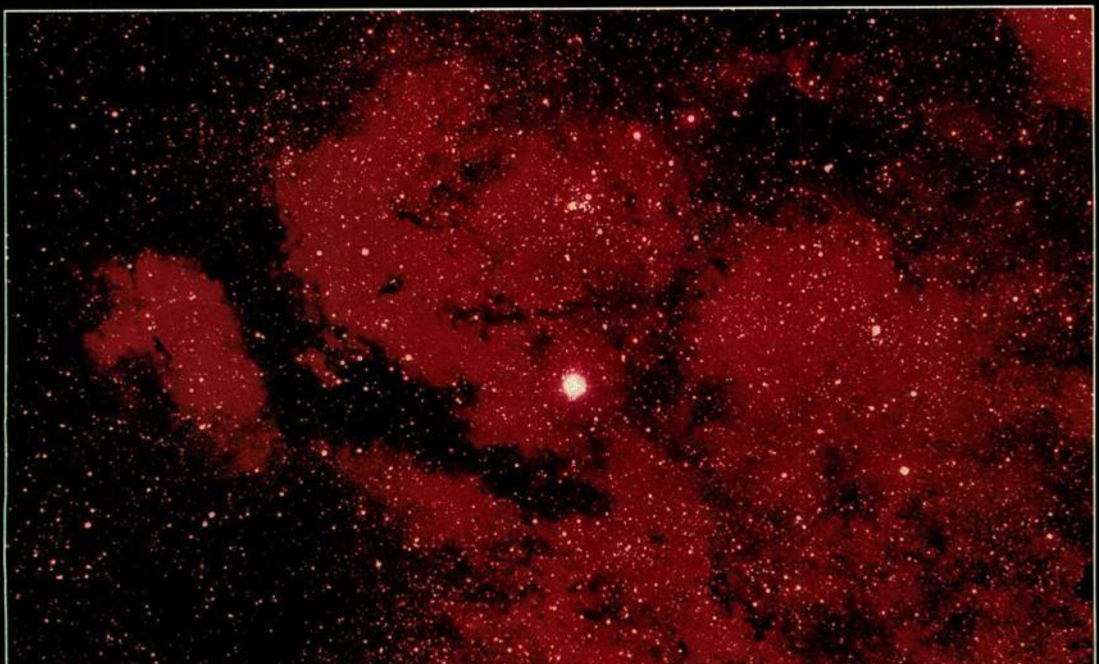
URBAN ASTROPHOTOGRAPHY can produce pleasing results, as evidenced by Paolo Candy's images of the Pleiades star cluster (below) and the Eagle Nebula in Serpens (above). Candy photographs from the balcony of his house in Viterbo, Italy.

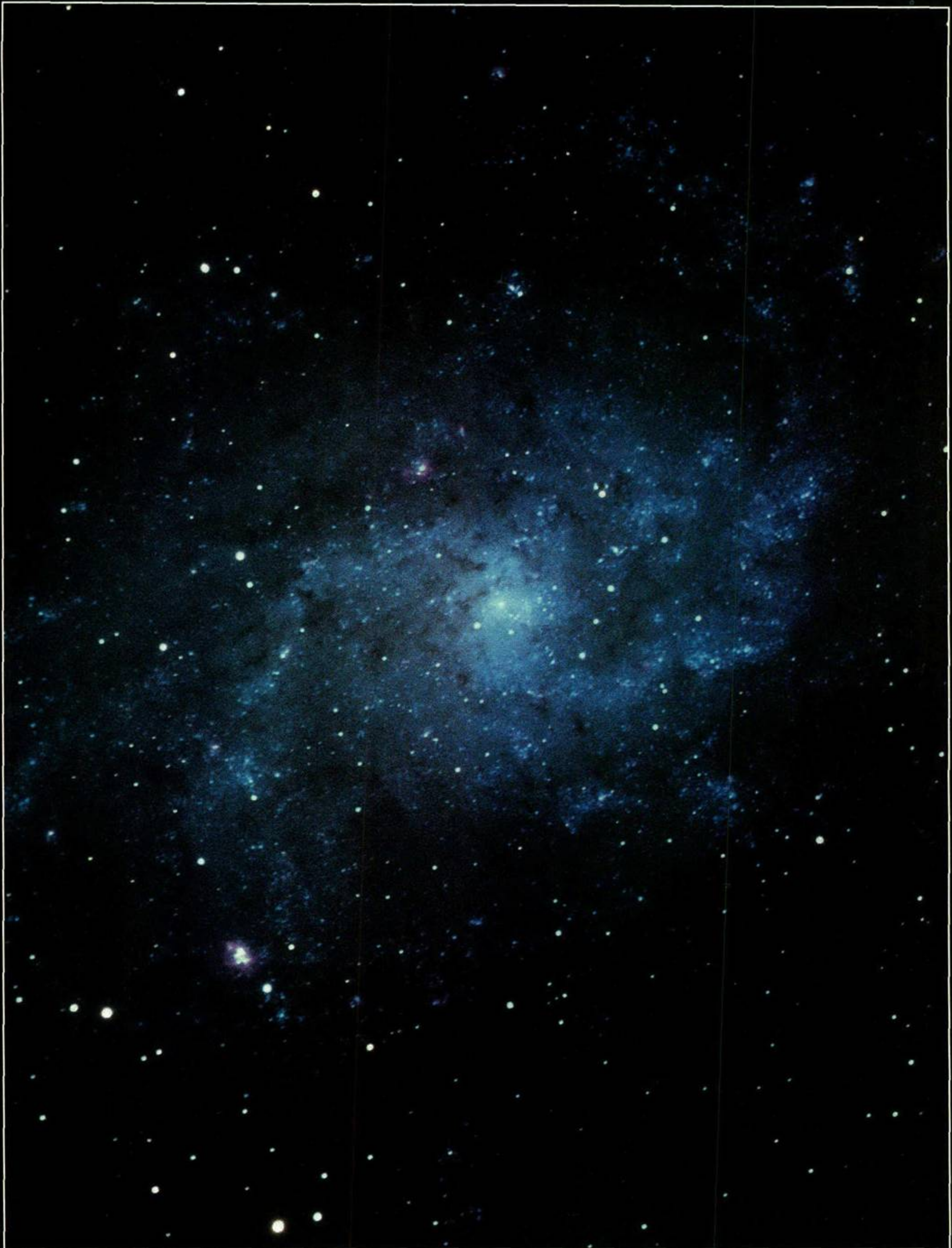
DEEP-SKY TREASURES

The heart of the Eta Carinae Nebula consists of a variegated combination of faint stars, brightly glowing hydrogen gas, and hot stars embedded in knots of nebulosity. Luke Dodd's photograph of the Eta Carinae Nebula (right) wins this month's $100 "Best Astrophoto" award. Dodd, of Singleton Heights, New South Wales, Australia, used a 4.7-inch refractor at f/8.5, hypersensitized Tech Pan film, and a 30-minute exposure to record the nebula's graceful form.

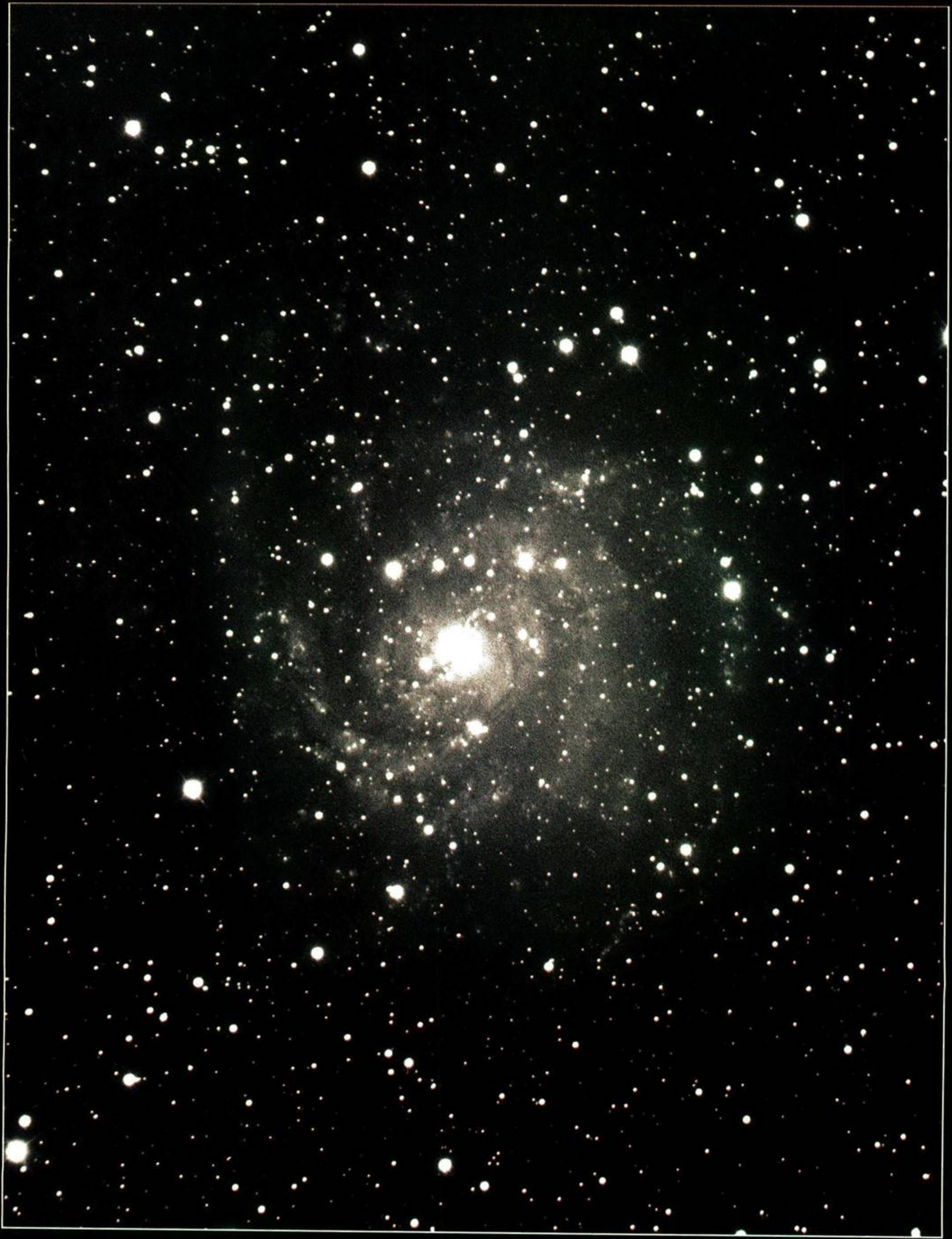
Other astrophotographers recorded beautiful regions of nebulosity over the past few months. George Greaney of Las Vegas imaged the glowing red clouds around Gamma Cygni, including IC 1318 (bottom). Jack Newton recorded the subtle, bluish color of Hubble's Variable Nebula (NGC 2261) with his 25-inch reflector and a CCD camera (below right). The wide expanse of ruddy nebulae in Cygnus was captured by Terence Dickinson (below). The galaxy NGC 6946, an object containing innumerable star clouds and nebulae, was recorded using a 20-inch Cassegrain and a CCD camera by Ronald W. Kohl (below, far right).







THE PINWHEEL GALAXY, M33 *in Triangulum*, is a challenging *sight for small telescope observers.* Las Vegas, Nevada, amateur George Greaney's photo of the Local Group spiral shows the delicate clumps of material in the galaxy's arms, the pinpoint nucleus, and several pinkish regions of emission nebulosity.



LOOSE, KNOTTY SPIRAL ARMS characterize the face-on galaxy IC 342 in Camelopardalis. The faint light from the galaxy's arms is nearly overwhelmed by a group of bright foreground stars. Photo by Kim Zussman.

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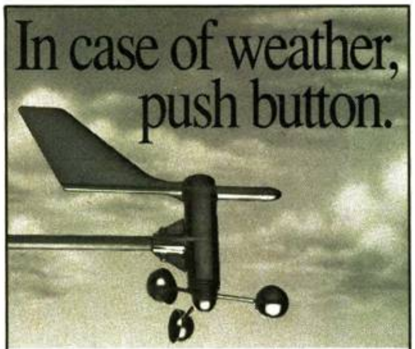

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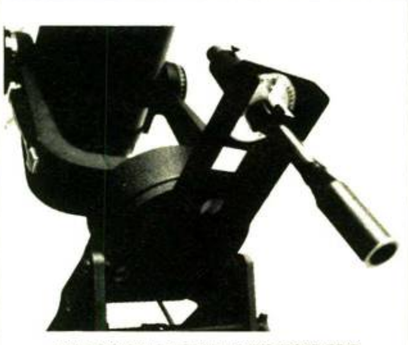

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Astronomy Books

SEARCH FOR LIFE

Is Anyone Out There? by Frank Drake and Dava Sobel, (Delacorte Press, 1992), ISBN 0-385-30532-X, 272 pages, hardcover, $22.

Drake, a noted radio astronomer, gives a personal view of the search for extraterrestrial intelligence (SETI), which makes this an enjoyable read and sets it apart from other books about astronomers' searches for other life forms. The story contains more than just a history of SETI from Project OZMA, the first search performed by Drake and others and named after the mythical land of Oz, to present-day efforts. It's also a chronicle about radio astronomy by a pioneer and the discoveries of pulsars and other astrophysical phenomena.

In addition to talking about how to receive messages from other worlds, Drake and Sobel describe what form these messages might take. They also describe the messages already sent by astronomers by radio toward the constellation Hercules and by recorded disks strapped to the sides of the Pioneer and Voyager spacecraft.

Drake shares his insights into the people and politics involved in making decisions about SETI and providing the funding for these projects. An appendix lists SETI projects from Project OZMA in 1960 to NASA's Microwave Observing Project started in 1992. A glossary helps the reader with some of the technical terms used in the book.

You'll find Drake and Sobel's narrative enchanting. While astronomers have yet to detect another civilization, Drake remains optimistic. Read this book and you will share his enthusiasm. — *Dave Bruning*

General Reading

The New Cosmos, from Astronomy Magazine, (Kalmbach Books, 1992) ISBN 0-913135-15-1, 160 pages, softcover, $19.95.

This richly illustrated book contains reprints from ASTRONOMY Magazine about our Galaxy and the universe, and collects in one volume all of the latest information about some of astronomy's greatest problems and mysteries.

Over 130 illustrations accompany the text, with each article reprinted in its entirety. Authors such as Ken Croswell, Gerrit Verschuur, Peter Jedicke, and David Levy describe recent ideas and findings about enigmatic quasars, black holes, dark matter, the big bang, a stellar collision in Orion, the supergiant star Rigel, how binary stars form, the center of our Galaxy, how the spiral arms of a galaxy form, what the recent COBE results tell us about the early history of the universe, and other facets of our glorious universe.

Aurorae

The Aurora Watcher's Handbook, by Neil Davis, (University of Alaska Press, 1992), ISBN 0-912006-59-5, 230 pages plus 27 color plates, acid-free paper, hardcover, $35; ISBN 0-912006-60-9, acid-free paper, softcover, $20.

Davis describes in simple terms the kinds of aurorae (northern lights), what causes them, how they change shape, and how to view them. Color plates show the different colors and shapes of aurorae, including artificial aurorae and ones seen from space. Davis discusses some of the folklore and legends surrounding the northern lights and investigates the mystery of the sounds heard by some aurora observers.

Stars

Stars, by James B. Kaler, (Scientific American Library, 1992), ISBN 0-7167-5033-3, 273 pages, hardcover, $24.95.

Kaler's book tells you everything you want to know about stars, from how they form to how they die. This richly illustrated volume describes the life cycle of stars, how they fit into the greater structure of the cosmos, and how astronomers learn these facts about these cosmic building blocks.

The technical descriptions and occasional mathematical formulae slant this book to the intermediate or advanced astronomer.

The Sun

The Sun in Time, edited by C. P. Sonett, M. S. Giampapa, and M. S. Matthews, (University of Arizona Press, 1991), ISBN 0-8165-1297-37, 990 pages, acid-free paper, hardcover, $60.

Thirty-six technical review papers by 83 authors from several scientific disciplines describe how the Sun has varied over time. The collection includes discussions of the sunspot cycle, the faint young Sun problem, and solar-terrestrial relations (glaciation and ice ages, sea sediments, and Earth's atmospheric response to the Sun's changing brightness). ☐

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FOR SALE — C5 with special coating, wedge, tripod, and case. Never used. Best offer. Contact Ed Case, 4495 Piedras St., Cocoa, FL 32927.

WANTED — *Atlas and Gazetteer of the Near Side of the Moon* by G. L. Gutschewski, D. C. Kinsler, and E. A. Whitaker. *Photographic Lunar Atlas* by G. P. Kuiper. Contact Ivor L. Clarke, 34 Frances Cresc., Bedworth, Nuneaton, Warwickshire CV12 8EW, ENGLAND.

FOR SALE — Meade 8" Model 50 with all supplied equipment, two 2-inch eyepieces, piggyback camera mount, Telrad, Olympus camera body, and t-mount. $1,600 including shipping in United States. Contact Mike Ford, 127 Roselawn, Holton, KS 66436. Phone (913) 364-2641 after 6 p.m. Central time.

FOR SALE — 3.5" Questar Standard with 8mm, 16mm, and 24mm eyepieces, camera coupling adapters, solar filter, and more. $2,200 or offer. Contact Skip Orr, 5 Prescelly Dr., Skowhegan, ME 04976. Phone (207) 474-5215.

WANTED — *Telescope Making*, issues 4 and 30. Contact Warren Tucker, 1900 N. Garland, #12, Fayetteville, AR 72703. Phone (501) 521-7336.

WANTED — Twenty-three-year-old female in Terceira Island, Azores, Portugal, would like to correspond with others who seek to understand the universe and whose ultimate dream is to reach out and touch the stars. Contact Kimberly A. Matos, PSC 76 – Box 2001, APO AE 09720.

WANTED — Pen pals interested in astronomy, geology, gemstones, meteorology, science fiction, stamp collecting, the environment, nature, book collecting, and/or jewelry making. Contact S. Anusiewicz, 120 Dennison Ave., Wyoming, PA 18644.

WANTED — Correspondents to discuss metaphysical, mystical, and moral implications consistent with cosmological theory. Other interests: writing, stargazing, ACOA issues. 56-year-old poet. Contact Richard E. Danner, R.D. 2, Box 215, Northfield, VT 05663.

WANTED — Layman, 44, interested in space art, baseball, cinefantastique, classical music, Indian classical dance, and Philippine folk dance would like to share ideas on the establishment of a permanent moonbase and the eventual terraformation of Mars, Venus, and Titan. Contact Earnest W. Jackson II, 125-10 Queens Bl., #501, Kew Gardens, NY 11415.

FOR SALE — Celestron C8 with 2 eyepieces, diagonal, tripod, and carrying case. $550. Meade 2045 spotting scope with eyepiece, 1¼ visual back, erector prism, carrying case. $250. Celestron C-90 with 3 eyepieces, diagonal, and carrying case. $200. Sears 60mm refractor with 6x30 finderscope. $50. Monolux 60mm refractor with diagonal. $50. Nikon binoculars, 10x50, 6.5° wide field, Sentinel series. $100. Model 80 High-lite binocular support system. $60. Contact Dennis Bohn, 208 Meadow View Rd., Mt. Horeb, WI 53572. Phone (608) 437-4442.

WANTED — Lick Observatory photos of the Moon, amateur lunar photography tips and suggestions, and information about obtaining very old lunar atlases and lunar maps. Contact Robert Derouin, 112 Brown Ave., Johnston, RI 02919.

FOR SALE — Tasco 4.5" f/7.9 reflector, various issues of ASTRONOMY, *Sky & Telescope*, *Deep Sky*, and *Telescope Making*, and *Build Your Own Telescope* by Richard Berry. $99. Contact T. Cardona, P.O. Box 39, Berrien Springs, MI 49103. Phone (616) 473-2991.

WANTED — Correspondence with radio astronomers to discuss design of antennae, amplifiers, receivers, data recorders, and software for radio observations. Also information on publications and groups interested in same. Contact Mark Humphrys, 2 Vivian Villas, Valnord Rd., St. Peter Port, Guernsey, Channel Islands, GREAT BRITAIN.

WANTED — Nineteen-year-old seeks correspondence with others interested in astronomy, cosmology, history, physics, or the social sciences. Contact JoyLynn Howie, 4626 Hampton, Royal Oak, MI 48073.

FOR SALE — Ten-inch 2120/LX3 Meade telescope with 4 eyepieces, solar filter, polar axis aligner, 2 nebular filters, off-axis guider, illuminated reticle eyepiece, Barlow, telecompressor, dew shield/zapper, and more. $1,750. Contact Tim Seaver, 1528 Seminary Ave., Apt. G, Woodstock, IL 60098. Phone (815) 337-4802.

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New Astronomy Products

1 Starsplitter Telescopes

Starsplitter II telescopes are custom-built Dobsonian reflectors employing a truss-tube design that breaks apart into easily handled components. Each telescope uses a Galaxy Optics primary mirror in an 18-point cell. Unique features include mounting plates for multiple finders and an adjustable counter-balance system for both heavy eyepieces and additional finderscopes. The upper-tube cage also nests in the low-profile primary box for compact storage. The first model introduced is a 20-inch f/5, shown, with a full range of apertures from 16 to 30 inches to follow.

Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362, (805) 493-2489. 20-inch model: $3,995 plus crating and shipping.

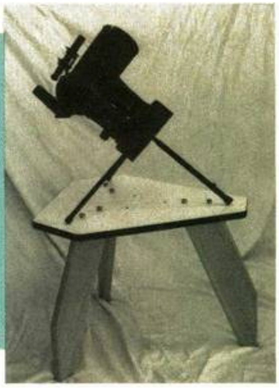
2 Ultra Wide Field Telescopes

COSMOS
UWF8

Cosmos has introduced a series of richfield Newtonian tube assemblies. Available in 4.25-, 6-, 8-, and 10-inch sizes, all are f/4 designs that provide fields of view of 2.3° to 4.4° (depending on the model). Each telescope features hand-corrected optics with surface accuracies stated to be better than 1/10-wave. All tubes are aluminum. Models of 6-inch or greater aperture feature 2-inch focusers.

Cosmos Ltd., 9215 Waukegan Road, Morton Grove, IL 60053, (800) 643-2351. 4.25-inch: $347; 6-inch: $495; 8-inch: $639; 10-inch: $895.

3 A Handy Stand for Tabletop Telescopes



The Quickstand is a telescope support designed for use with 3.5- to 5-inch catadioptric telescopes with tabletop tripods or wedges. The height allows for comfortable observing while seated. The wood Quickstand breaks down for transport in its heavy 24" x 22" denim pack, which is included.

T.A.V.A. Designs, P.O. Box 1332, Springfield, OH 45501, (800) 225-2179. $74.50 plus $8.75 shipping.

4 Astroslide Lesson Sets

Astroslides are strips of 8 or more laminated 35mm images of astronomical photographs or spectra. A second strip contains various scales and grids that overlay the first set and allow the student to make measurements of solar rotation rates, binary star periods, Doppler shifts, and the age of the universe. Astroslides require the special viewer that uses neither electricity nor batteries. Ten slide sets are available on a range of topics from telescopes to galaxies.

National Teaching Aids, Inc., 1845 Highland Avenue, New Hyde Park, NY 11040, (516) 326-2555. Slide sets: $9.60 each; viewer: $7.50. Add 15% for shipping and handling. Volume discounts available.

5 A Cool Telescope Cover

The new line of Desert Storm Shield telescope covers are made of lightweight, tear-resistant Mylar that reflects sunlight. The covers will keep a telescope as much as 20 degrees cooler than the air temperature and protect it from rain, dew, and dust. They are available in sizes to fit most popular telescopes from 8-inch Schmidt-Cassegrains up to giant 25-inch Dobsonians. Call or write for a complete list of sizes and prices.

AstroSystems, Inc., 1109 Kimbark Street, Longmont, CO 80501, (303) 678-5339. Prices from $19.95 to $56.95 plus postage and handling.

TWO 19th CENTURY OBSERVATORIES OF IRELAND
Fall, 1992

6 *Journal of the Antique Telescope Society*

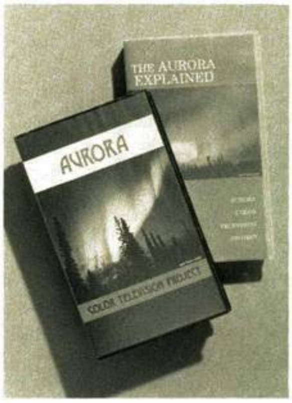
The newly formed Antique Telescope Society offers members a quarterly journal with feature articles about classic telescopes, old astronomy books, and related topics. Membership includes a subscription to the journal and is open to anyone with an interest in antique instruments and the history of astronomy.

Antique Telescope Society, c/o Walter Breyer, secretary, 30 Green Valley Road, Wallingford, PA 19086. One-year membership/subscription: $40; student membership (18 or younger): $25; associate membership: $10; club membership: $40.

7 Aurora Videos

The Aurora Color Television Project at the University of Alaska's Geophysical Institute has produced a second videotape as a sequel to their successful 27-minute *Aurora* video. The new production, *The Aurora Explained,* is a 30-minute narrated documentary that answers the most frequently asked questions about aurorae. Both videos use footage shot with a low-light-level TV camera that shows the colors of aurorae and auroral motions in true speed.

Aurora Color Television Project, Geophysical Institute, Room 614C, University of Alaska, Fairbanks, AK 99775-0800, (907) 474-7462. The Aurora Explained and Aurora (both VHS format): $30 each plus $4 each for postage and handling.



8 Steiner Rallye Binoculars

Available as 6x30, 8x30, 7x50, and 10x50 models, the new Rallye series of binoculars features a streamlined body design that incorporates the same glass type and shock-absorbing polycarbonate frame found in all other Steiner models. The optics are fully coated and feature 17mm or more of eye relief. Field of view and weight of each model is: 6x30: 8.6° and 19 oz; 8x30: 7.4° and 17 oz; 7x50: 7° and 37 oz; and 10x50: 6.2° and 36 oz. All have individual-focus eyepieces.

Steiner Binoculars, c/o Pioneer Marketing and Research, 216 Haddon Avenue, Suite 522, Westmont, NJ 08108, (609) 854-2424. 6x30: $399; 8x30: $399; 7x50: $649; 10x50: $649. ☐

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.

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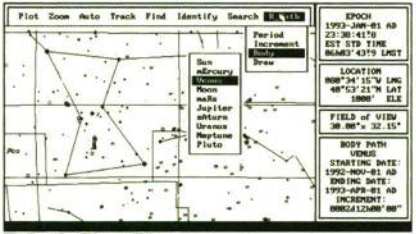

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GLASS - *TYPE 1 (Full Aperture)*

Made from high quality hand select glass, machine polished and TRIPLE COATED with a Nickel-Chromium alloy (same as Inconel). Mounted in a machined aluminum cell ready to attach to telescope. Solar image is yellow-orange. No secondary filtering is necessary.

Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS - *TYPE 2 (Full Aperture)*

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	119.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00

40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS - *TYPE 3 (Full Aperture)*

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
12.5" to 13.1"	229.00	12.5" to 13.1"	209.00
14"	259.00	14"	239.00

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Types 1 & 2 are for unlimited visual use and general photographic use. Instructions included with all filters, including tips on solar photography.

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Texas Star Party, Prude Ranch, near Fort Davis, Texas. Hosted by the Southwest Region of the Astronomical League. Contact: TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002.

May 28-31
Riverside Telescope Makers Conference, Camp Oakes, Big Bear, California. Contact: RTMC, c/o Fox and Stephens, CPA, 9045 Haven Avenue #109, Rancho Cucamonga, CA. Phone: (714) 948-2205.

June 4-6
82nd Spring Meeting, Berkeley, California. Sponsored by the American Association of Variable Star Observers. Contact: Janet A. Mattei, 25 Birch Street, Cambridge, MA 02138. Phone (617) 354-0484.

June 5
45th Annual Convention of the Northeast Region of the Astronomical League, Springfield Science Museum, Massachusetts. Sponsored by the Springfield Stars Club. Contact: Ray Burk, 19 Sunset Rock Road, Wilbraham, MA 01090.

June 11-12
8th Annual Sedona-Verde Valley Astronomy Festival, Red Rock State Park (between Sedona and Cottonwood). Contact: Professor Nidley, Director, 1101 Zalesky Road, Cottonwood, AZ 86326. Phone (602) 634-7332.

June 11-12
Apollo Rendezvous and Telescope Fair, Dayton Museum of Natural History. Contact: Miami Valley Astronomical Society, 5932 Culzean Drive #706, Dayton, OH 45426, Ian Dumbauld, (513) 837-4600.

June 11-13
1993 Convention of the Midstates Region of the Astronomical League, Wesleyan University, Lincoln, Nebraska. Co-hosted by the Prairie Astronomy Club and Nebraska Wesleyan University. Contact: Richard Johnson, 1860 Pawnee Street, Lincoln, NE 68502.

June 12 – 19
Grand Canyon Star Party, Grand Canyon National Park. Contact: Dean Ketelson, c/o Tucson Amateur Astronomy Association, P.O. Box 41254, Tucson, AZ 85717.

June 15-19
1993 Southeastern Planetarium Association Conference, Bishop Planetarium, Bradenton, Florida. Sponsored by the Bishop Planetarium. Write to the Bishop Planetarium, South Florida Museum, 201 10th Street West, Bradenton, FL 34205. Phone (813) 746-4132.

June 18
Stairway to Heaven, Ward Pound Ridge Reservation, Cross River. Contact: Robert Davidson, Westchester Amateur Astronomers, P.O. Box 111, Chappaqua, NY 10514. Phone (914) 238-4533.

June 18-20
1st Annual Star Party, Sola Fide Observatory, Austin, Minnesota. Sponsored by the Cedar River Astronomy Club. Contact: Keith Snyder, 407 15th Street, S.E., Austin, MN 55912. Phone (507) 433-1903.

June 18-20
4th Annual Mason-Dixon Star Party, Spring Valley County Park near York, Pennsylvania. Sponsored by the York County Parks Astronomical Society. Contact: Todd Ullery, R.D. #1, Box 5AA, Glen Rock, PA 17327. Phone (717) 235-1153.

June 18-20
Jersey Star Quest IV, Beemerville 4-H Camp off Route 519 (near High Point State Park), Sussex, New Jersey. Sponsored by the Amateur Astronomer's Association of Princeton, Inc. (AAAP). Contact: Greg Mauro, P. O. Box 2017, Princeton, NJ 08543. Phone (609) 585-9465

June 18-20
Wisconsin Observers' Weekend, Hartman Creek State Park, Waupaca. Write to NEWSTAR, the Northeast Wisconsin Stargazers, 1815 Kienast Avenue, Oshkosh, WI 54901, Don Wyman, (414) 233-3083.

June 19-August 28
International Space University Summer Session, Huntsville, Alabama. Sponsored by the University of Alabama in Huntsville. Write to International Space University, 955 Massachusetts Avenue, Cambridge, MA 02139. □

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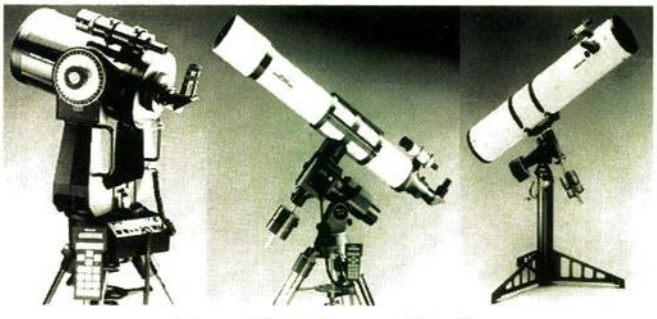

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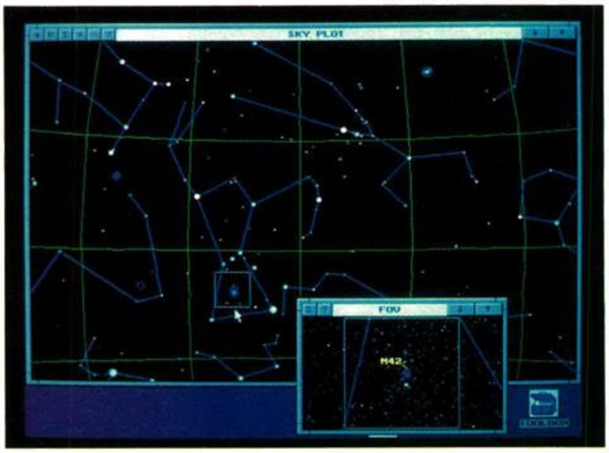

ASTRONOMY: Darla Gawelski

***StarGaze* (2.1),** *CEB Metasystems, 1200 Lawrence Dr., Suite 175, Newbury Park, CA 91320. Phone (800) 232-7830. Price: $99.95. Minimum requirements: IBM PC-compatible computer, 640 KB memory, DOS 3.3, mouse, EGA display, and hard disk with 6 MB of free space. A math coprocessor is recommended and 10 MB of hard disk space are needed to load the entire database. Software comes on 3 1/2" diskettes; additional charge for 5 1/4" replacement diskettes. Optional Sky Catalogue 2000.0 data set: $39.95; SAO catalog: $49.95.*

StarGaze is a planetarium-type program that has two strong features. A field-of-view window lets you plot a finder or eyepiece view of the sky shown in the main window. You can control magnitude limits and objects plotted for the two windows separately. And the database includes over 500,000 stars from the *Hubble Guide Star Catalog* and over 9,000 radio sources and deep-sky objects from the Messier list and the New General Catalogue. You can plot stars down to 10th magnitude over the entire sky and down to 16th magnitude in selected fields.

The program shows the sky for any date between 4,713 B.C. to A.D. 10,000 and animates planetary motions so you can watch eclipses and conjunctions. Be careful though — the planet animation uses a different date and time than the sky map. A lunar calendar is also available. Zooming in on planets, though, is a disappointment — no moons to watch orbiting Jupiter and no Saturnian rings to see. The planetary database doesn't include any comets or asteroids.

If you're using this program at a telescope, choose the red-lit display screen. And you can invert the maps or reverse them left for right to correspond to your eyepiece view.

If you're used to Windows or menu-driven programs, you'll find this user interface different. It uses a series of tools to move around the program. A search tool (generally using lists) lets you find a planet, deep-sky object, or constellation. And an information tool prints out the name, position, magnitude, and other information about any object you click on.

Star names include common names and Bayer (Greek letter) designations, but you can add other labels. The tools are easy to use, but the mouse tools (for example, for zooming and identifying objects) require that you click on the tool each time you use them. The tool reverts to a pointer instead of retaining its last function. Also the position tool lists right ascension in degrees instead of the more common hours and minutes.

Printing star charts requires creating a print file and then exiting StarGaze to run a separate print utility program. While this may be faster if you're producing lots of maps, it's not very convenient if you're trying to print a finder chart for an observing session. However the print quality even in medium-resolution mode on a LaserJet printer is good. And the print utility lets you customize star sizes and grid line widths, and produce mosaics from several maps.

Improvements to this program in future versions should include a list of cities for the observer's location so you can explore eclipses and events from different locations. Presently you have to type in your latitude and longitude. The precession tool should have a button to allow you to precess to the date of observation and not just to today's date or 2000.0 (in the current version you have to retype the date). The zoom-out key should go back in steps, not immediately back to the whole-sky map.

Consider StarGaze if you want a planetarium program that has a large database of deep-sky objects and will plot stars down to 16th magnitude in selected regions. Its price is more than reasonable considering the databases. — *Dave Bruning*

NEW SOFTWARE

***MICA**, U. S. Naval Observatory, distributed by National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Phone (703) 487-4650. Price: $55, plus $3 handling fee per order. Minimum requirements — DOS version: IBM PC-compatible computer, DOS 2.0, 512 KB memory, and hard disk with 2 MB free space (8 Mhz processor or faster and math coprocessor are recommended); Mac version: Mac Plus, 1 MB of memory, System 6.0.2, and 2 MB of hard disk space (math coprocessor and 68020 processor are recommended). Both 5 $^1/_4$" and 3 $^1/_2$" disks are provided with the DOS version.*

The Multiyear Interactive Computer Almanac (MICA) provides high-precision astronomical data for computer users. Simple menus lead you to planetary positions and configurations; the magnitudes, illuminations, and central meridians of the planets; the times of sunrise, sunset, and twilight; and the rising and setting times of astronomical objects. MICA replaces the Interactive Computer Ephemeris and the Floppy Almanac and matches the accuracy of the yearly editions of *The Astronomical Almanac*. It features data for a ten-year interval from 1990 through 1999 and uses the DE200/LE200 solar system ephemeris developed by the Jet Propulsion Lab.

***Binary Maker (2.0)**, Contact Software, 725 Stanbridge St., Norristown, PA 19401-5505. Phone (215) 279-1940. Price: $59.95, plus $4.95 for shipping and handling. Minimum requirements: IBM PC-compatible computer, 640 KB memory, and VGA monitor. Math coprocessor strongly recommended. Binary Maker supports only PostScript printers.*

Explore how the brightnesses and orbital speeds of stars in binary systems change as the stars orbit each other. To make the simulations more interesting, you can add dark or bright spots on the stars' surfaces. You can also plot the brightnesses and orbital velocities of the stars and compare them with data from real binary systems. Binary Maker includes information from more than 40 binaries for comparison and uses circular orbits for the stars.

Aldus PhotoStyler Now Supports Kodak Photo CDs

PhotoStyler is a Windows-based image-processing program. An accessory pack is now available that provides full support of Kodak's Photo CDs. (See New Astronomy Products in the March issue for information about Photo CDs.) The pack also contains ImagePals Album, an image manager that enables the user to catalog and browse through images stored on a hard drive or CD-ROM. Registered PhotoStyler users were mailed the free accessory pack in December 1992. New users will receive the pack when they register the program. For more information, contact Aldus, 411 First Avenue South, Seattle, WA 98104-2871, or phone (206) 622-5500.

***Ceres**, Zephyr Services, 1900 Murray Avenue, Pittsburgh, PA 15217. Phone (800) 533-6666 or (412) 422-6600. Price: $159.95, plus $4 shipping. Minimum requirements: IBM PC-compatible, EGA display, and a hard disk with 7 MB free space.*

Asteroid positions are the major feature of this program. It includes the orbital elements of more than 5,000 asteroids, and you can add to the database. You can produce a table of an asteroid's sky coordinates for different dates, map its path through the sky, or plot its orbit around the Sun. A zoom function allows you to see the path in greater detail.

Ceres uses a database of over 200,000 stars for its sky maps. You can identify each star, which is useful for investigating occultations of stars by asteroids. The observatory database contains the locations of over 450 observatories, or you can enter your site so you can calculate accurate topocentric positions (referenced to Earth's surface instead of Earth's center).

Correction

The review for The_Sky in the May issue incorrectly listed the address for Software Bisque. It is 912 Twelfth Street, Suite A, Golden, CO 80401. Or phone (800) 843-7599. ☐

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David Broad, Santa Barbara, Ca.

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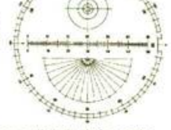

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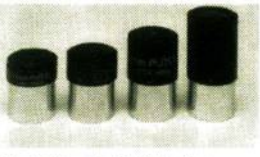

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WANTED — Correspondence with C-8 owners and astrophotographers to exchange ideas. Contact Diane Mullin, 1628 W. James Street, Norristown, PA 19403. ☐

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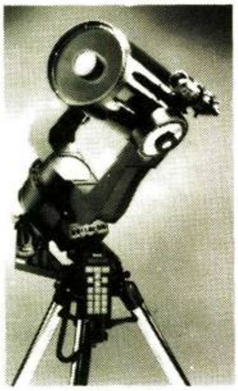

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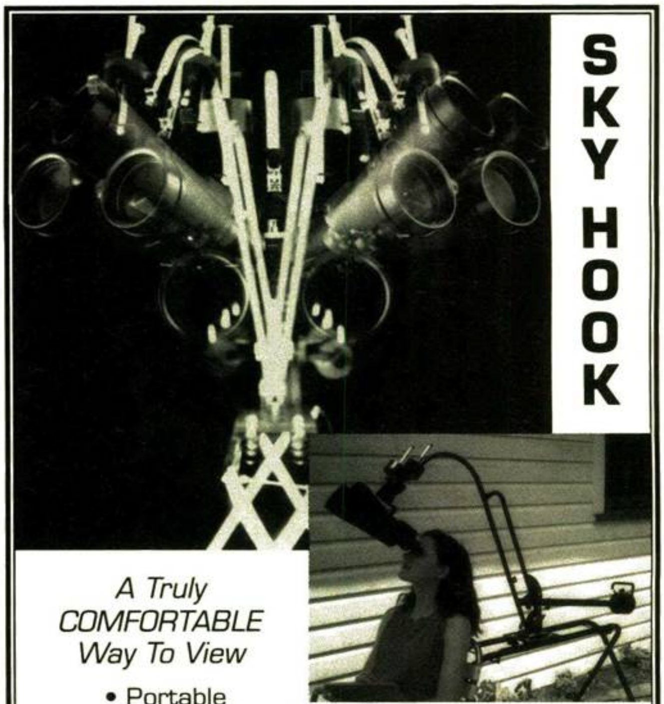

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Readings & Credits

The Sands of Mars (page 26)

Mars, edited by Hugh Kieffer, Bruce Jakosky, Conway Snyder, and Mildred Matthews, (University of Arizona Press, 1992). An enormous (1,400 pages) but thorough and up-to-date summary of Mars knowledge.

The Surface of Mars, by Michael Carr, (Yale University Press, 1981). More than a decade old but still the best pictorial and summary work on Martian surface processes.

Wind as a Geological Process on Earth, Mars, Venus, and Titan, by Ronald Greeley and J. D. Iversen (Cambridge University Press., 1985).

Aeolian Sand and Sand Dunes, by K. Pye and H. Tsoar (Unwin and Hyman, 1990).

Choosing Eyepieces (page 56)

The Backyard Astronomer's Guide, by Terence Dickinson and Alan Dyer, (Camden House, revised 1993). A guide to the hobby and to selecting equipment. Contains a chapter on choosing eyepieces and filters.

Exploring the North Polar Sky (page 68)

Discover the Stars, by Richard Berry, (Harmony Books, 1987). An introductory book that leads you on a tour of all the stars and constellations visible to the naked eye.

The Digital Universe (page 74)

Choosing and Using a CCD Camera, by Richard Berry, (Willmann-Bell, Inc., 1992). A guide to selecting the right camera for your application as well as detailed instructions for taking images. Includes software for image calibration.

Astronomical Image Processing, by Richard Berry, (Willmann-Bell, Inc., 1991). Image-processing software with thorough manual that explains the basics.

"Going Digital with Color," by Richard Berry, ASTRONOMY, July 1992. An introduction to creating color images from calibrated black-and-white CCD images.

"The Digital Darkroom: 'Developing the Image,'" by Richard Berry, ASTRONOMY, March 1993. Tells how to create a calibrated CCD image by taking flat-field and dark frames.

"The Digital Darkroom: 'Printing the Image,'" by Richard Berry, ASTRONOMY, April 1993. Explains how to enhance CCD images with image processing software.

Cover: National Optical Astronomy Observatories; ***p. 4:*** Frank Zullo; ***p. 18, left:*** D. Gezari, G. Kopp, and W. Livingston; ***right:*** P.N. Appleton/Fick Observatory, Iowa State University; ***p. 20:*** Thomas L. Hunt and Dave Bruning; ***pp. 22:*** USAF/DODD; ***p. 23, left:*** K. Roettiger, et al., New Mexico State University; ***right:*** Ohio State University and the National Radio Astronomy Observatory; ***p. 24:*** Robert Burnham; ***p. 26-27:*** Paul Hudson; ***p. 29:*** (top to bottom) Viking 1 frame 94A47, Viking 2 frame 524B23, Viking 2 frame 516B64, all NASA/JPL; ***p. 30:*** Viking images processed by Alfred McEwen, U.S. Geological Survey, Flagstaff; ***pp. 32-33:*** Viking images processed by Paul Geissler, Lunar and Planetary Laboratory, University of Arizona; ***p. 34:*** (top left) Viking 1 frame 709A42, (top right) Viking 2 frame 575B60, (lower right) Viking 1 frame 716A12, (bottom left) Viking 2 frame 510B73, all NASA/JPL; ***p. 36:*** courtesy of Thomas Steiman-Cameron; ***p. 37, top:*** Allan Sandage, courtesy of Thomas Steiman-Cameron; ***p. 37, bottom:*** John Kormendy, courtesy of Thomas Steiman-Cameron; ***pp. 38-39:*** Tom Hunt, from an original photo by James Wray; ***pp. 40-41:*** all photos copyright Anglo-Australian Telescope Board; ***p. 42:*** both photos courtesy Abhijit Saha STScI, and NASA; ***p. 43:*** courtesy National Optical Astronomy Observatories; ***p. 48:*** Mark Payne-Gill; ***p. 56:*** Chris Becker; ***pp. 57-65:*** equipment photos by Darla Gawelski; artwork by Phil Kirchmeier; ***p. 68:*** L. H. Price; ***p. 69-73:*** all maps by Steven G. Davis; ***p. 72:*** David J. McGlaun, Jr. ***p. 74, top:*** Tim Hunter; ***middle and bottom:*** George Fowler; ***p. 75, top:*** Jack Newton; ***bottom:*** Richard Berry; ***p. 76, top:*** Richard Berry; ***all planet images:*** Gregory Terrance; ***p. 77, Cas A:*** Paul Boltwood; ***Ring Nebula:*** Ronald Kohl; ***NGC 7008:*** Jack Newton; ***Dumbbell Nebula:*** Paul Boltwood; ***p. 78, NGC 5907:*** Ronald Kohl; ***all other images:*** Jack Newton; ***p. 79, top:*** Tim Hunter; ***bottom:*** Ronald Kohl; ***p. 81:*** Paolo Candy, astrophotos made with 8-inch SCT at f/6.3, 3200 ISO film, and 30-minute exposures; ***p. 82, top left:*** Ronald W. Kohl, 20-inch Cassegrain, STAR I CCD camera, 4-minute exposure; ***bottom left:*** Terence Dickinson, 85mm lens at f/1.7, Scotchchrome film at ISO 800, 2-minute exposure; ***top right:*** George Greaney, 5-inch refractor at f/5.9, hypersensitized Fuji Super HG 400 film, integration print made from two 60-minute exposures; ***bottom right:*** Jack B. Newton; ***p. 83:*** Luke Dodd, 4.7-inch refractor at f/8.5, hypersensitized Tech Pan film, 30-minute exposure with minus violet filter; ***p. 84:*** George Greaney, 14-inch SCT at f/7, hypersensitized Tech Pan film, integration print made from two 60-minute exposures; ***p. 85:*** Kim Zussman; ***p. 103:*** Michael Stecker

COMING IN THE JULY 1993 ISSUE OF

ASTRONOMY

Michael Stecker

DANCE OF THE DOUBLE SUN Did the Sun form when two smaller stars merged? Observing a remarkable binary system suggests this idea isn't too far-fetched.

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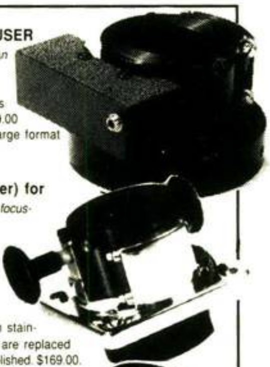

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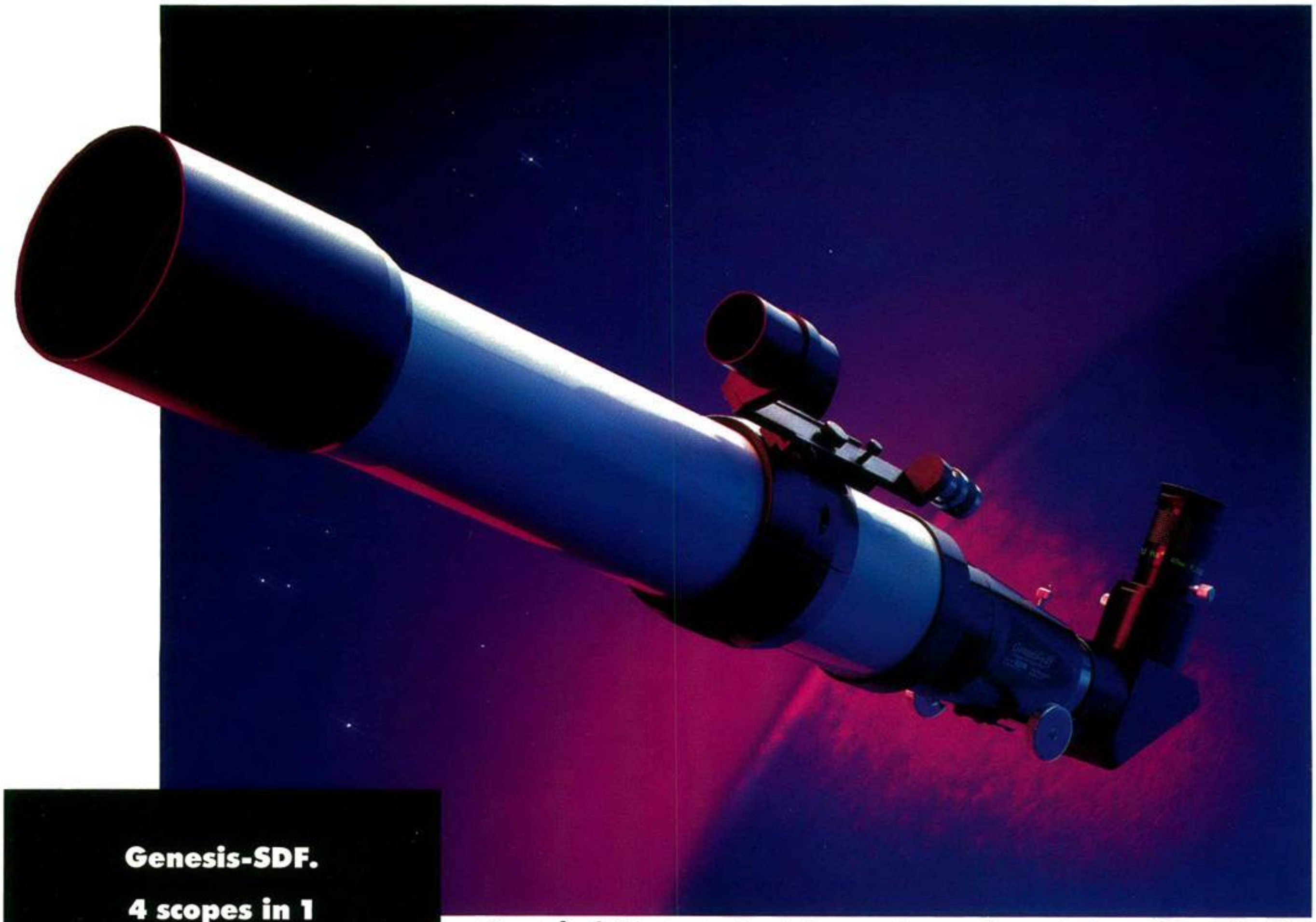

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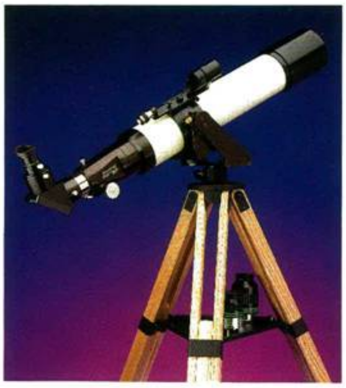

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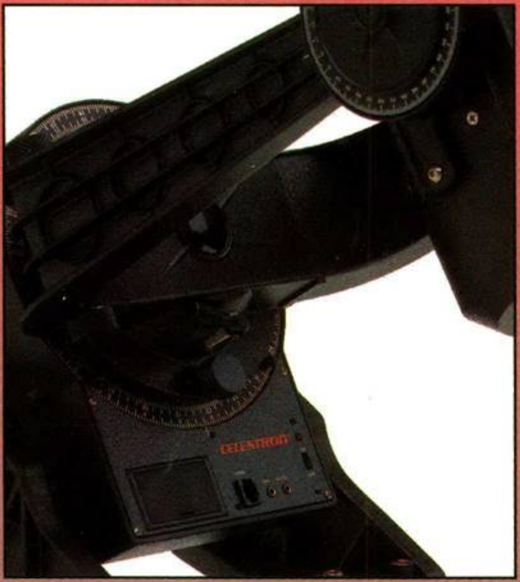
Celestron

Definitely A Plus



Telescope Shown is the new C8+ (#11013) and close-up of the simplified clock drive base cover panel

Introducing the C8+

If you are looking for – a first telescope – to move up in aperture (remember, there is no substitute for aperture!) – to upgrade your vintage 1970's or 1980's 8" to the 1990's technology – look no further – the new C8+ is made just for you!

8 reasons to buy the C8+ now!
8 reasons that only Celestron offers!

- **Simplicity** – a sophisticated design but simple and fun to use. No complex bells or whistles to slow you down or confuse you. Just quickly set up your C8+ and enjoy yourself and our Universe.
- **Electronics** – the most advanced state-of-the-art design and runs off of a single 9-volt alkaline battery for over 50 hours. No cords or wires to get in your way or auxilliary batteries or converters to carry with you.
- **Optics** – superior optics (8" f/10 Schmidt Cassegrain) which are consistently the finest made. Now all 8" Celestron optics use high quality ***optical crown glass*** for the corrector lens which gives you less light scatter and much higher contrast.
- **Portability** – the complete telescope with equatorial wedge weighs just 28#. The field tripod supplied weighs just 9-1/2#. Ideal for the astronomer on the go.
- **Quality Control** – the most stringent in the industry.
- **Photo Accessories** – the most advanced optional astrophotographic accessories offered.
- **Visual Accessories** – the most advanced observational accessories offered.
- **Dual Focal Ratio** – for a limited time as a ***special introductory offer,*** all buyers of the C8+ will receive ***free*** the Reducer/Corrector f/6.3. You can choose the standard f/10 or f/6.3 with the 4-element multi-coated focal reducer and field corrector lens. At f/6.3 you will have sharper images, not severe aberrations and loss of contrast inherent in dedicated f/6.3 systems. A value of $250. See your local Celestron dealer for details.

For literature and a complete description of the C8+ and the C8+ Computerized telescope, contact your local Celestron dealer or contact Celestron.

CELESTRON®

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LIGHT YEARS AHEAD OF THE COMPETITION

New Computerized Telescope

Celestron is proud to also introduce the C8+ Computerized telescope (#11014). The proven quality of the Advanced Astro Master is incorporated with the C8+ to give you an economical computerized telescope. 8000+ object memory and more — and it runs off a single 9-volt battery for 30+ hours. Each unit is thoroughly tested at the factory before shipment.